# SCIENCE 14

## MODULE 1: SCIENCE & TECHNOLOGY

MODULE 1: SCIENCE & TECHNOLOGY
MODULE 1: SCIENCE & TECHNOLOGY
MODULE 1: SCIENCE & TECHNOLOGY

Distance Learning

Alberta EDUCATION

Science 14

Module 1

# SCIENCE AND TECHNOLOGY

Distance Learning

Alberta EDUCATION

Science 14
Student Module
Module 1
Science and Technology
Alberta Distance Learning Centre
ISBN No. 0-7741-0297-7

Cover photograph reprinted by permission of Fotostudio PimWesterweel, Naarden, Netherlands.

# Welcome to Science 14!

We hope you'll find this course interesting and fun.

To make your learning a bit easier, a teacher will help guide you through the material.

So whenever you see this icon,

turn on your audiocassette and listen.

# Contents


**OVERVIEW** ..... 1

Evaluation ..... 2

**SECTION 1:**

**ORIGINS OF TECHNOLOGY** ..... 3

Activity 1: Recognizing Needs and Wants ..... 5

Activity 2: What If the Technology Wasn't Present? ..... 8

Activity 3: Is Everything Already Invented? ..... 10

Activity 4: Science and Technology – Which Comes First? ..... 11

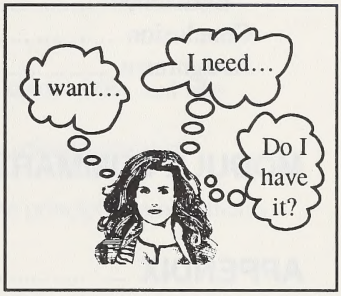
Follow-up Activities ..... 14

Extra Help ..... 14

Enrichment ..... 15

Conclusion ..... 16

Assignment ..... 16



**SECTION 2:**

**DESIGNING TECHNOLOGY** ..... 17

Activity 1: Observing Nature ..... 19

Activity 2: Establishing a Scientific Law ..... 24

Activity 3: Using the Principles ..... 30

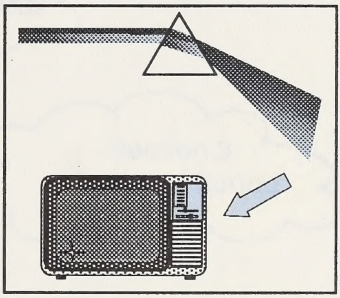
Follow-up Activities ..... 34

Extra Help ..... 34

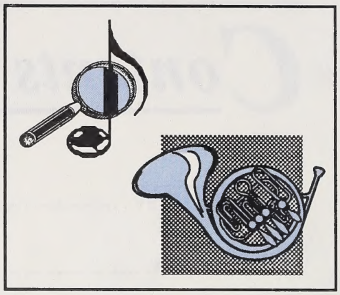
Enrichment ..... 35

Conclusion ..... 38

Assignment ..... 38

## SECTION 3:




**LIGHT AND SOUND** ..... 39

Activity 1: The Energy of Light – Intensity and Colour .... 41

Activity 2: Applying the Theory ..... 44

Activity 3: Focussing Light ..... 50

Activity 4: Optical Instruments ..... 57

Activity 5: Sound – Theory and Reflections ..... 63

Activity 6: Musical Instruments ..... 70

Follow-up Activities ..... 83

Extra Help ..... 84

Enrichment ..... 85

Conclusion ..... 86

Assignment ..... 86

**MODULE SUMMARY** ..... 87

**APPENDIX** ..... 89

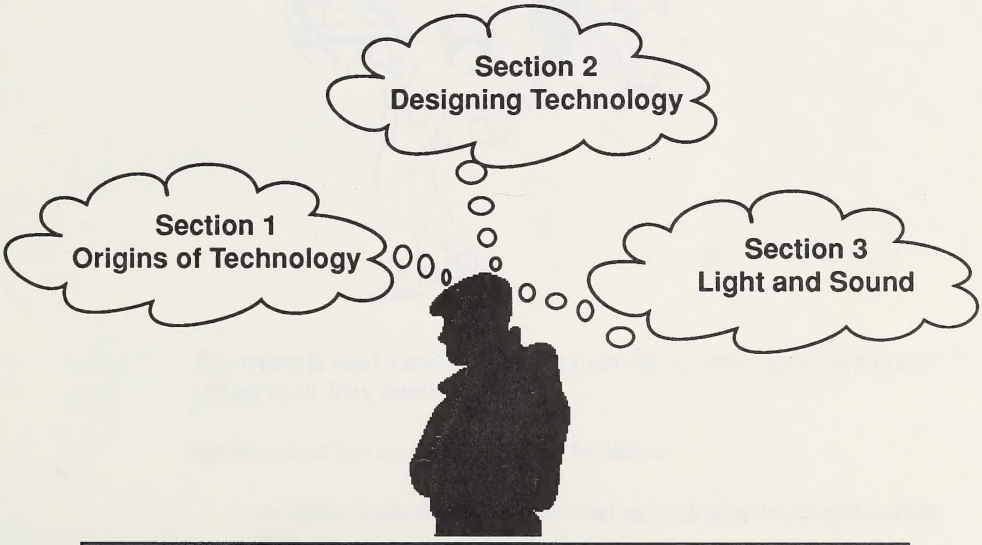
## OVERVIEW

Everyone uses technology. It may be obvious, like using a stereo or a car, or not so obvious, like using a shovel or a baseball bat.

Technology is not only the things you use or science at work. It's almost an extension of ourselves. People have cranes to help them lift things, microphones to make their voices carry farther, cars to get them from place to place, and computers to help them think.

In this module you should

- come to understand where technology comes from, and why
- see how observing things can lead to a scientific inquiry
- carry out a scientific inquiry to find the principles upon which a technology is founded



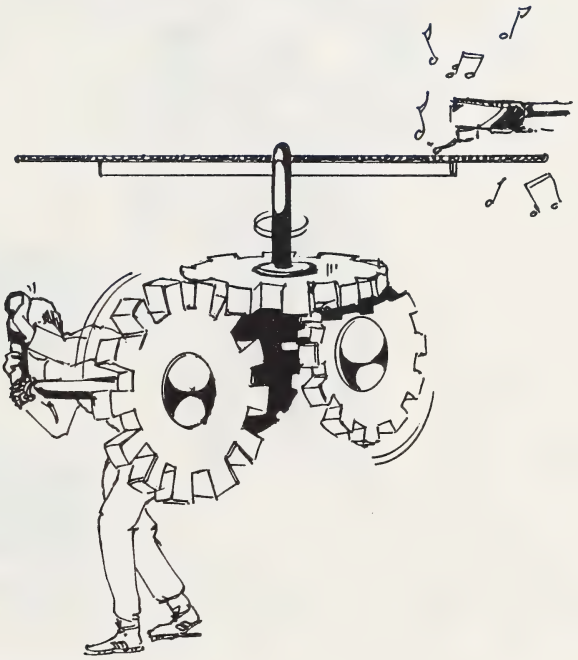

**MODULE 1**
**SCIENCE AND TECHNOLOGY**

## Evaluation

Your mark in this module will be determined by your work in the Assignment Booklet. You must complete all assignments. In this module you are expected to complete three section assignments. The assignment breakdown is as follows:

| | | |
|---|---|---|
| Section 1 | = | 25 marks |
| Section 2 | = | 35 marks |
| Section 3 | = | 40 marks |
| TOTAL | = | 100 marks |

# 1 Origins of Technology

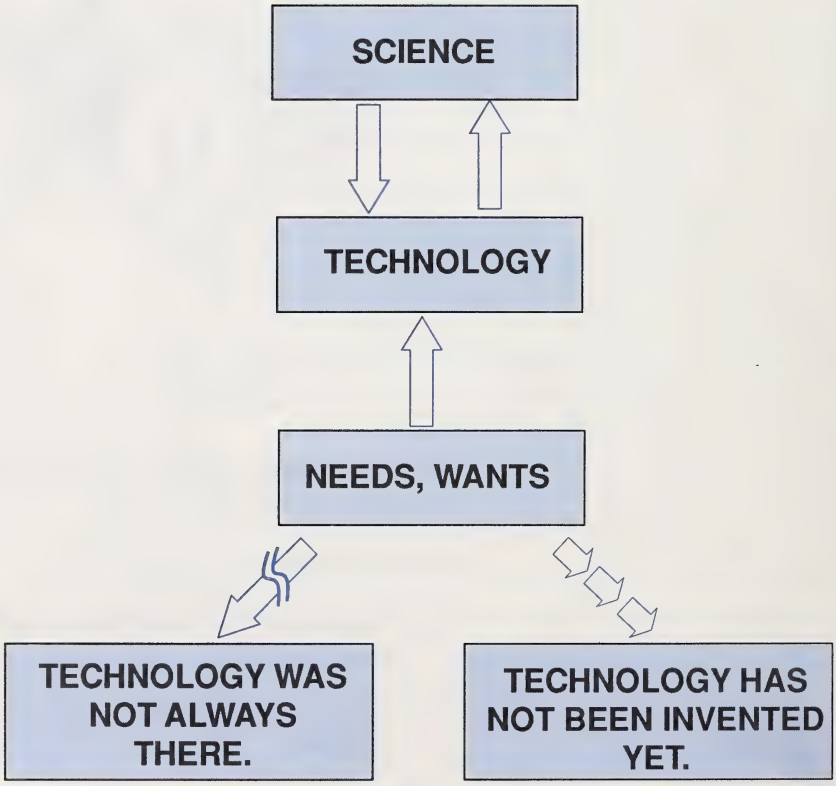


When people need something, or want something, they buy it. If it is not around at all, they invent it.

By the end of this section you should be able to

- recognize some needs that have had technologies developed to meet them
- recognize some needs that have **not** had technologies developed to meet them
- invent a device or technology to meet a need
- learn the relationship between science and technology

As you work through this section, remember needs and wants will stimulate new technologies.



## Activity 1: Recognizing Needs and Wants


**technology -** science at work, applied science, all the inventions and techniques people have developed to solve practical problems

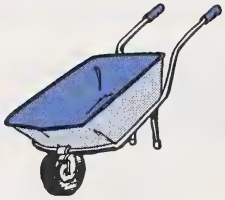
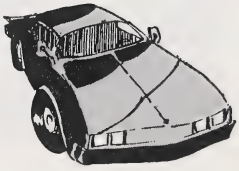
**Technologies** are developed to satisfy needs. Humans need to eat. The plow was invented to help farmers plant crops. The metal plow was a huge advancement over the wooden plow.

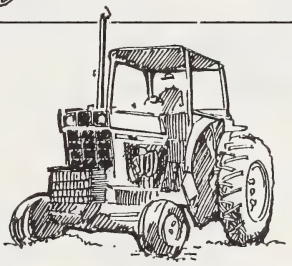
The portable cassette tape player was designed so people could listen to their tapes anywhere. Do they need to? No, but they want to. Technology responds to people's wants as well as their needs.

1. Name a device or a technology that is satisfying the needs or wants described in the chart.

| Need (Want) | Technology or Device |
|---|---|
| cook food outdoors | |
| cook food indoors | |
| lift a car to change a tire | |
| see very small things | |
| push a fridge up into a truck | |
| have sure-footing when playing games | |
| stay warm outside at $-40°C$ | |
| stay up when in water | |

2. Complete the chart by describing a need or want that these devices are satisfying.

| Device | Need (or Want) |
|---|---|
|  | |
|  | |

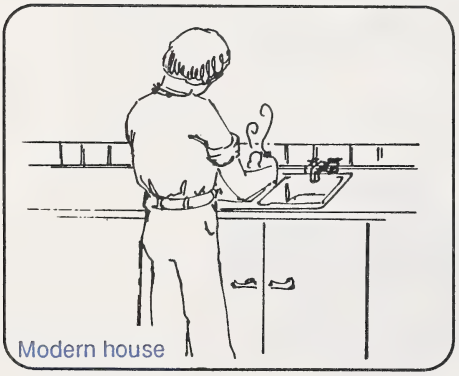
| Device | Need (or Want) |
|---|---|
|  | |
|  | |
|  | |
|  | |
|  | |

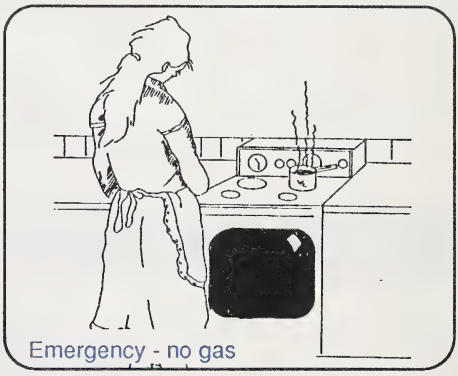
| Device | Need (or Want) |
|---|---|
|  | |

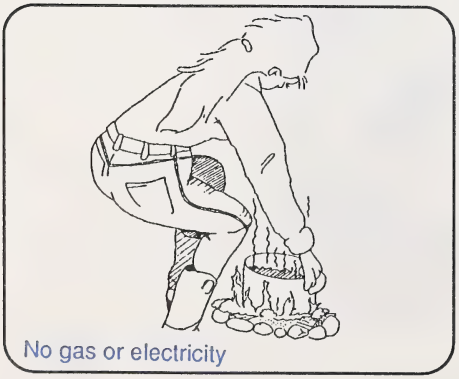
Check your answers by turning to the Appendix, Section 1: Activity 1.

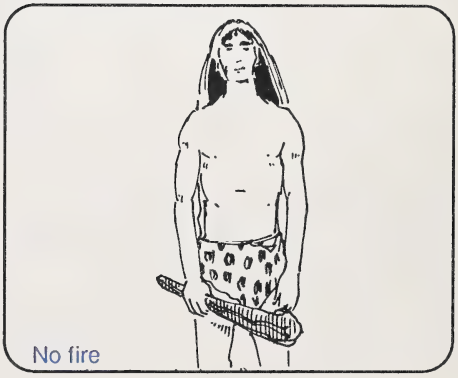
## Activity 2: What If the Technology Wasn't Present?

Look at these pictures and imagine that you are the person in them. You have been asked to get a cup of hot water.


Modern house


Emergency - no gas


No gas or electricity


No fire

People take much of the technology for granted. However, if the technology is not available, even simple tasks are hard to do.

Describe how you would go about performing a simple task under the following conditions. You must choose one of the tasks.

Task 1 – Lift a heavy boulder 2 m.

**or**

Task 2 – Read in bed at night.

**or**

Task 3 – Listen to some music performed by your favourite band.

**Task chosen:** _____

**Condition 1:** You have today's technology to use.

_____

_____

**Condition 2:** Use anything you like, except electricity.

_____

_____

_____

**Condition 3:** Use only what your body can do.

_____

_____

_____

_____

Check your answers by turning to the Appendix, Section 1: Activity 2.

## Activity 3: Is Everything Already Invented?

1. Try to think of three needs that you or other people have for which the technology has not been developed yet. It's not easy to do. An example might be a solar-powered passenger plane.

   List them here.

   _____

   _____

   _____

2. Suppose you were asked to invent or design a device to satisfy one of these needs. What problems would you run into?

   _____

   _____

   _____

   _____

   _____


Check your answers by turning to the Appendix, Section 1: Activity 3.

## Activity 4: Science and Technology – Which Comes First?

The term *science* is used to mean *research science*. It is a method of learning about nature. Technology is applied science, or science at work. For example, someone might be doing research on rubber with no thought as to what good, or bad, might come of it. Someone else might use that research to make a rubber sole for running shoes.

The technology we have comes from science, but the **opposite is also true**.

**SCIENCE ADVANCES TECHNOLOGY.**

**TECHNOLOGY ADVANCES SCIENCE.**

Look at some examples. First look at science leading to advances in technology.

Physicists predicted the laser 50 years before it was built.

Motors couldn't be made until the electric theory behind them was figured out.

Thomas Edison invented the electric chair to discourage the use of A.C. electricity.

Sonar was invented from sound theory to fight the German submarines in World War II.

Now look at examples of technology advancing science.

Working steam engines were built before the theory behind them was in place. The theory came from the engines.

Sonar allowed scientists to map the ocean floors. The data from that proved the theory of continental drift and plate tectonics.

The computer has been used in almost all fields of research.

Science and technology work together to help each other. Advances in research science go hand in hand with technological advances.

Write S → T if the following example shows how science advances technology.
Write T → S if it's an example of technology advancing science.

1. The Voyageur II spacecraft sent back pictures of Neptune. _____

2. A robot submarine showed pictures from the deepest ocean trenches. _____

3. Research on spiders' webs led to a way of making synthetic fibres. _____

4. Chemical research provided the basis for the development of photography. _____

Check your answers by turning to the Appendix, Section 1: Activity 4.

Just how scientific inquiry can lead to technological progress is the subject of Section 2.

## Follow-up Activities

If you had difficulties understanding the concepts in these activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

### Extra Help

- When humans need something they get it somehow.
- Technology is all the things that people have made to help them do the things they need to do.
- Technology is invented to satisfy our needs and wants.

1. Choose words from Column B to complete the statements in Column A.

| Column A | Column B |
|---|---|
| a. Humans need to eat. Technologies developed to satisfy this need are _____ , _____ , and _____ . | mirrors<br>plows<br>radios<br>tractors<br>televisions<br>refrigerators<br>satellites<br>toothpaste<br>combs |
| b. Modern society needs to communicate at a distance. Some technologies developed to satisfy this need are _____ , _____ , and _____ . | |
| c. People want to look good for their friends. Technologies developed to satisfy this want are _____ , _____ , and _____ . | |

2. Put the following technologies in order from the earliest to the most modern technology: space shuttle, fire, electricity, and roads.

Early ⟶ Modern

_____ → _____ → _____ → _____

Check your answers by turning to the Appendix, Section 1: Extra Help.

## Enrichment

1. Write a description of how you would cook a meal consisting of meat, potatoes, and corn, if you couldn't use electricity or natural gas.

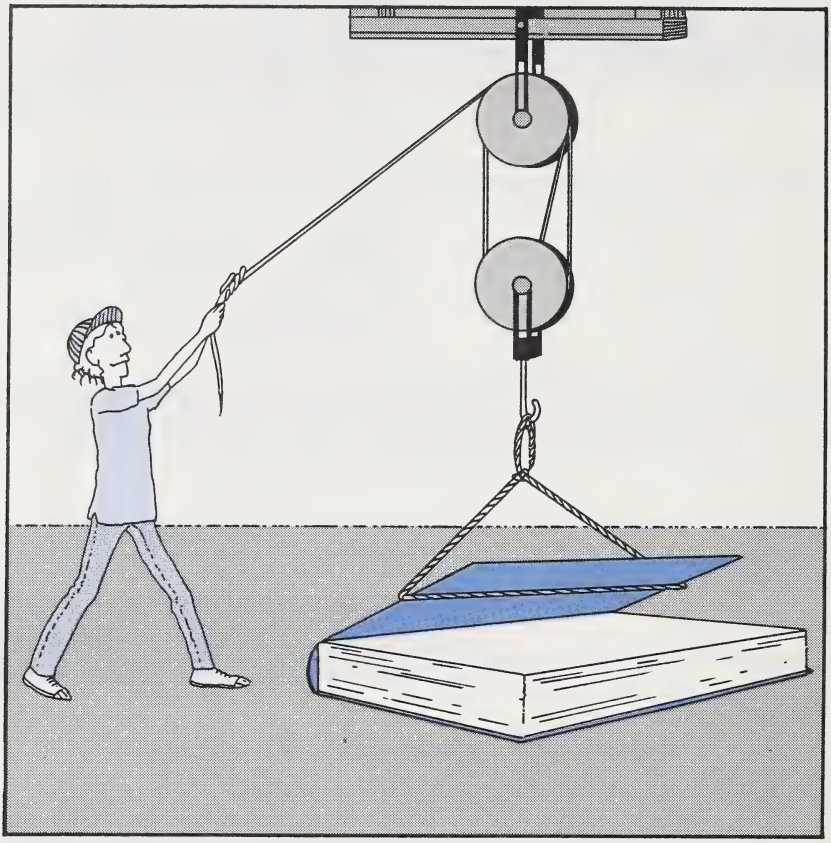
**or**

2. Draw a diagram of a kitchen that might have been found in early Alberta (before 1900).

Check your answers by turning to the Appendix, Section 1: Enrichment.

## Conclusion

In this section you looked at where technology comes from. Human needs and wants were found to be the driving force behind the development of technology. Science and technology develop together.



Assignment Booklet

### ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 1.

# 2 Designing Technology

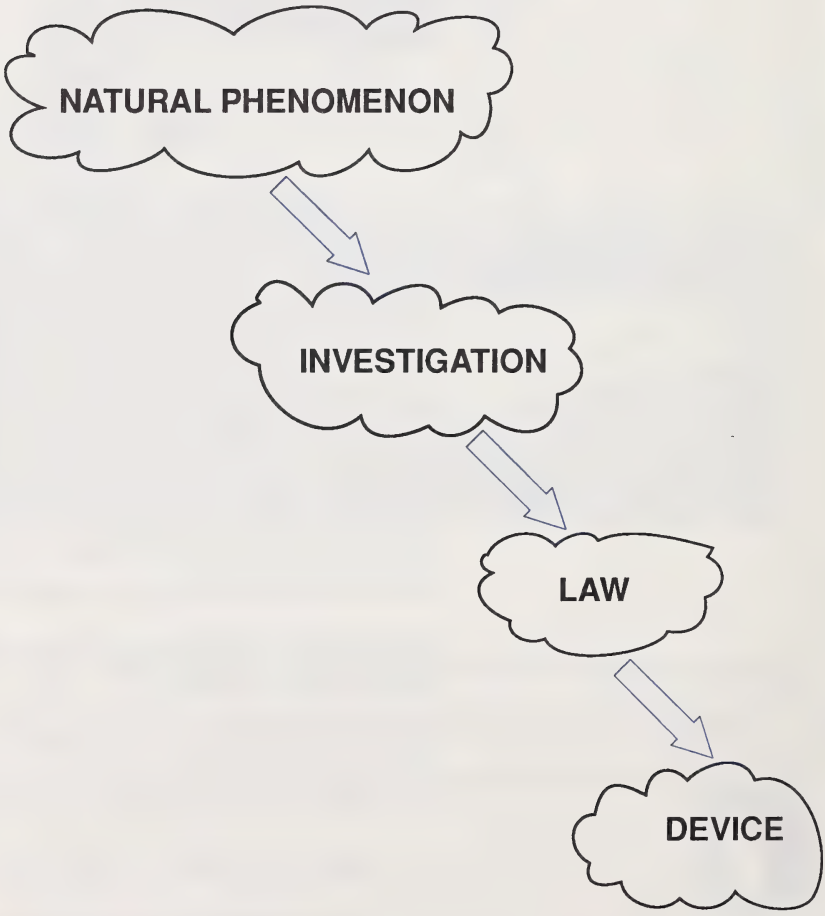

Can you imagine being Thomas Edison inventing the electric light bulb or Galileo making a telescope that could let him see the moons of Jupiter? How much did they know before they invented their devices?

In this section you will learn how to begin studying nature in order to figure out how to make something.

By the end of this section you should be able to

- understand the terms *facts*, *laws*, and *theories*
- recognize a few laws of natural things
- see the relationship between these laws and how they work in some devices

The following diagram illustrates how this section is organized. Have a look at it now.

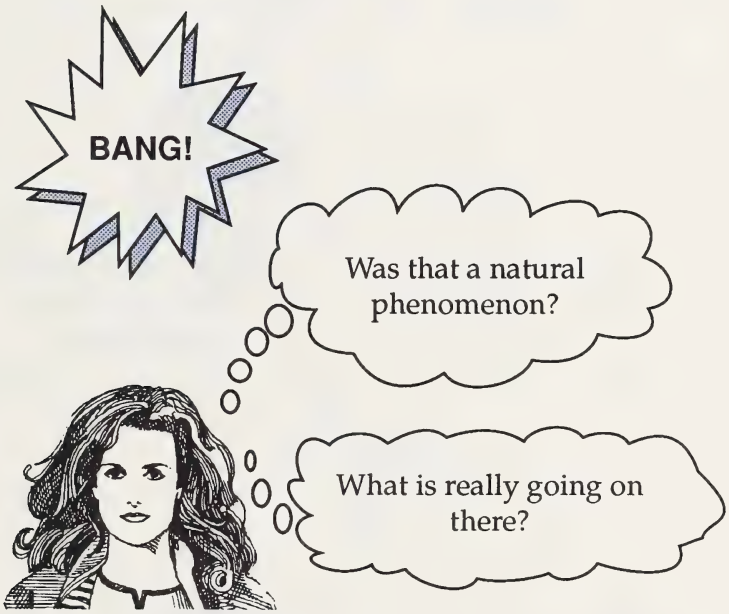


## Activity 1: Observing Nature

**phenomenon (plural phenomena)** - any fact, event, or experience; anything that occurs

Anything that happens in nature is a natural **phenomenon**. There are millions of them. You will be asked to select a few natural phenomena and study them. Here are a few examples of natural phenomena:

a rainbow
light
thunder
electricity
a tornado
sound
an insect's buzz



When a natural phenomenon occurs over and over, people start to see a pattern in the event. For example, when lightning strikes, a noise (thunder) follows. If the lightning is close, the thunder follows right away, but if the lightning is far away, the thunder is heard a bit later.

Can you tell how far away a lightning strike is?

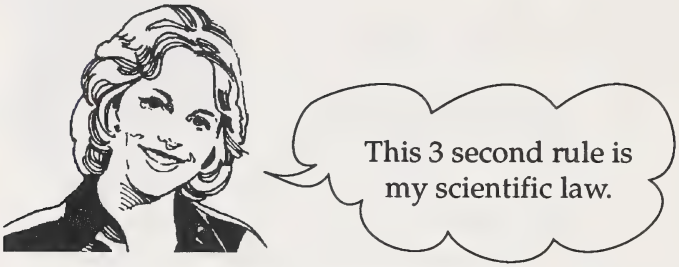
Sure. Count seconds until you hear the thunder and...

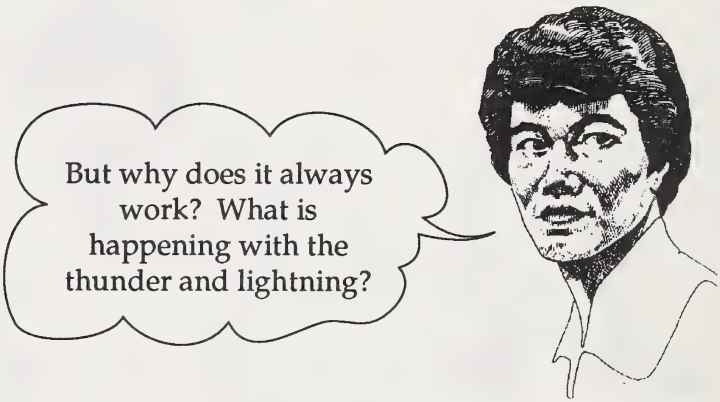
For every 3 seconds of time between the lightning and thunder, lightning is about 1 km away.

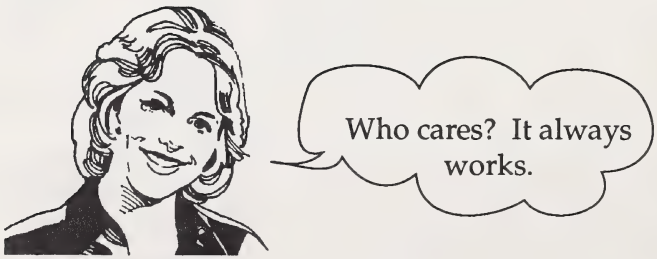

one – two – three – four – five – six!
BOOM!
Hmm... 6 ÷ 3; that one was 2 km away!
BOOM!!
Wow! That one was close.

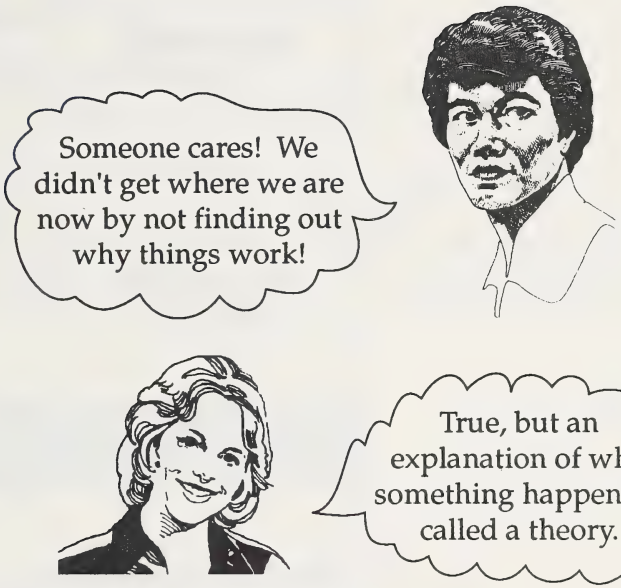
**law** - a rule of science, or an established principle, based on observing an event

When scientists can state a rule based on observing an event (or events), they call it a scientific **law**. A law describes events. It does not explain the theory behind the law.






**theory** - an explanation of why events occur as they do

Therefore, a law describes events and a **theory** explains them.

1. As an aid in helping you remember the new terms, write their definitions in the following spaces.

   a. phenomenon: _____

   _____

   b. law: _____

   _____

   c. theory: _____

   _____

2. Write *theory* or *law* beside these statements.

   a. Light travels in straight lines. _____

   b. Lights travels faster than sound; that is why the thunder is heard after the lightning is seen. _____

   c. A high C musical note has a shorter wavelength than a low C note. _____

| | | |
|---|---|---|
| SCIENTIFIC LAW | ⇨ | THIS WORKS |
| SCIENTIFIC THEORY | ⇨ | THIS WORKS BECAUSE... |

Check your answers by turning to the Appendix, Section 2: Activity 1.

## Activity 2: Establishing a Scientific Law

You are going to find a law about a natural phenomenon. You must choose **one** of the following investigations to do. Investigation A is about light, and Investigation B is about sound.

### Investigation A: Light

Does light always travel in straight lines? How can you test this? It is not easy to see a light beam. You can see a beam of light if it goes through dusty air (as in a sunbeam) or through cloudy water.

#### Materials You Need

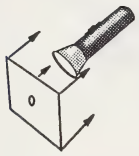
- flashlight
- heavy paper or cardboard
- clear drinking glass or other container
- mirror
- cornstarch
- water
- scissors or a sharp knife

## Steps to Follow

First, make a light beam.

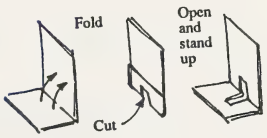
**STEP A**

Fit a piece of paper with a hole in it over the flashlight. The hole can be about 0.5 cm.



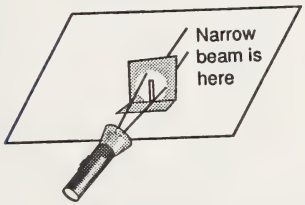
**STEP B**

Cut a narrow slit in another piece of paper. Make it about 1 cm high and 2 mm wide.




**STEP C**

Line them up as shown, and you will have a narrow beam of light.



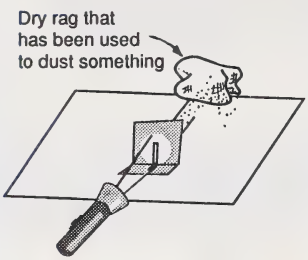

**STEP D**

If you want to have a more mobile beam, you can use a milk carton. Cut the top off and cut a slit in the bottom. Attach it to the flashlight.

Now try some tests.

**STEP E**

Set the beam up on a table and sprinkle some dust **above** the beam. Diagram what you see.




**OBSERVATION**

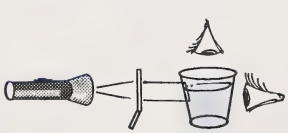
Draw the beam after it gets through the slit.

**STEP F**

Put a pinch of cornstarch in a glass of water and stir it. The mixture should be cloudy.

**STEP G**

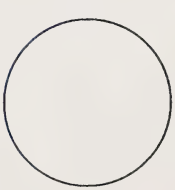
Turn the lights off and shine the beam through the glass. Observe it from above and from the side. Diagram what you see.



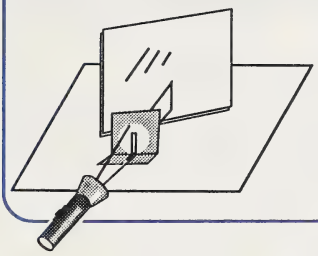
**OBSERVATION**

Draw the beam in the water from

above



the side

| STEP H | OBSERVATION |
| --- | --- |
| Set the beam on the table again and stand a mirror up in the beam's path. Diagram what you see.  | Draw the beam as it hits and leaves the mirror. |

| STEP I | OBSERVATION |
| --- | --- |
| Shine the beam down onto the water's surface as shown. Diagram what you see.  | Draw the beam as it enters the glass from above. |

Note: It may be necessary to stir the cornstarch mixture occasionally to keep it cloudy.

Check your answers by turning to the Appendix, Section 2: Activity 2.

**pitch** - how high or low a sound is
A female voice is usually higher in pitch than an adult male voice.

## Investigation B: Sound

Does the size of an object have any effect on how high or low a sound it makes? How high or low a sound is, is called its **pitch**. Pitch is **not** how loud the sound is.

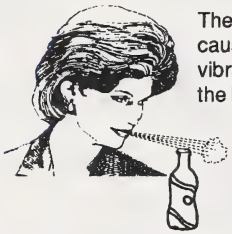
### Materials You Need

- pop bottle (any size)
- spoon
- any drinking glasses (made of glass)

### Steps to Follow

**STEP A**

Blow across the top of the pop bottle until you get a note. It takes a bit of practice.



The note is caused by the vibrating air in the bottle.

**STEP B**

Add water until the bottle is about one-third full. Blow the note again. Is it higher or lower than before? Is the size of the airspace in the bottle larger or smaller?

**STEP C**

Fill the bottle two-thirds full and try again. Answer the same two questions as in step B.

1. As I put more water in the bottle, the pitch went _____ .
2. As I put more water in the bottle, the size of the air space _____ .

**STEP D**

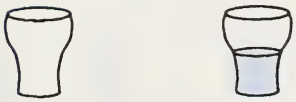
Take the spoon and gently tap several different sizes of glasses. Draw a diagram of them and write *high pitch*, *medium pitch*, or *low pitch* beside the diagrams.

**OBSERVATION**

Draw several glasses and describe the pitch made by tapping them.

**STEP E**

Take a large juice glass and tap it. The sound you hear is the glass vibrating. Fill the glass half full of water and repeat. Note the sound.



**STEP F**

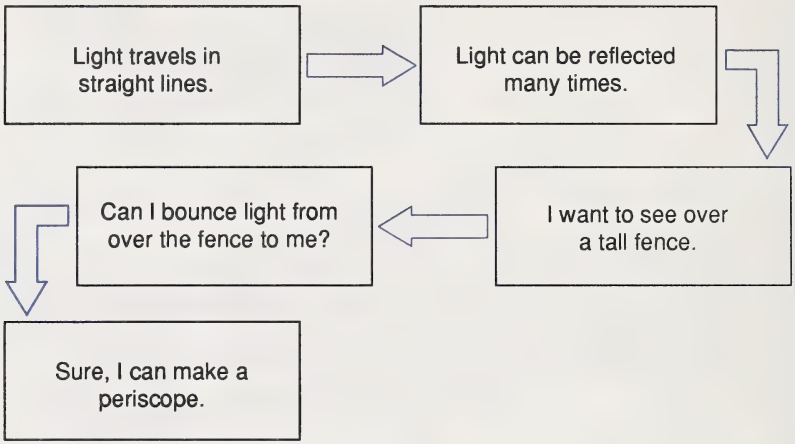
The sound in step E is the glass and water vibrating. Fill the glass to the top and try again. Describe the pitch of the sound.

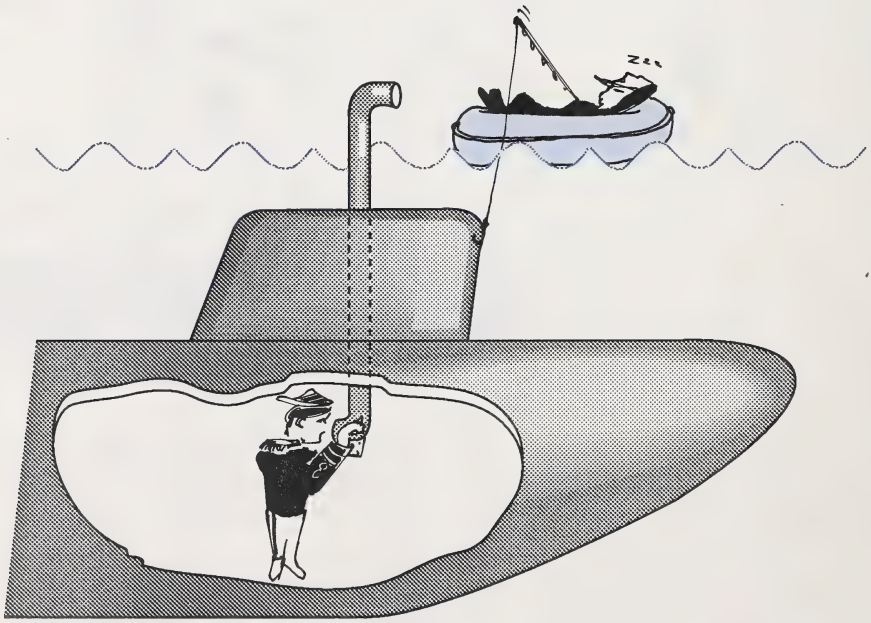
3. As more water is put in the cup, the pitch _____ .
4. The biggest difference in pitch happens when the water is _____ .

Check your answers by turning to the Appendix, Section 2: Activity 2.

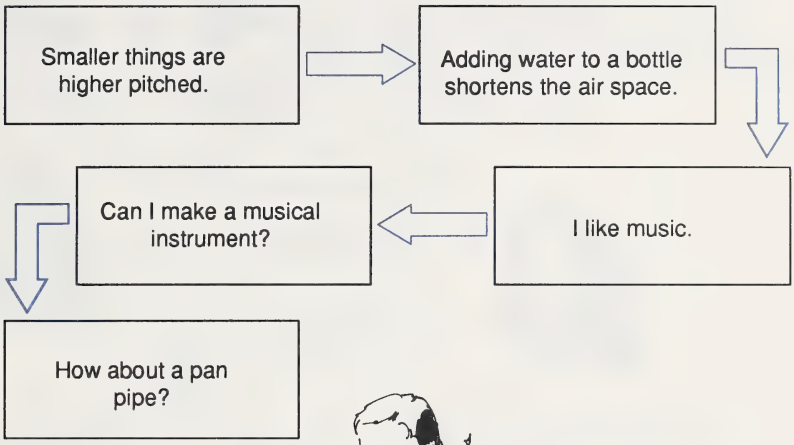
## Activity 3: Using the Principles

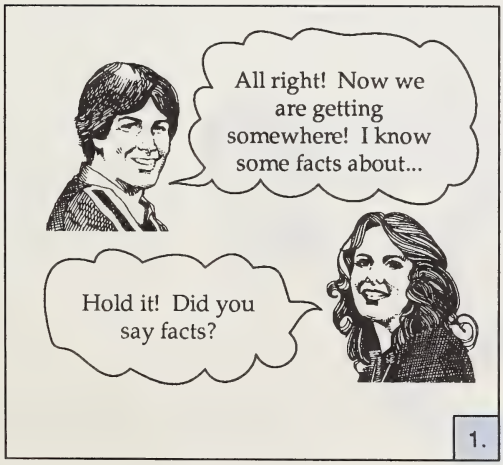
You learned something about sound and light in the last investigation. Can you do anything with your knowledge? The answer is *yes*. Once you understand a little about how something behaves, you can put that knowledge to work.

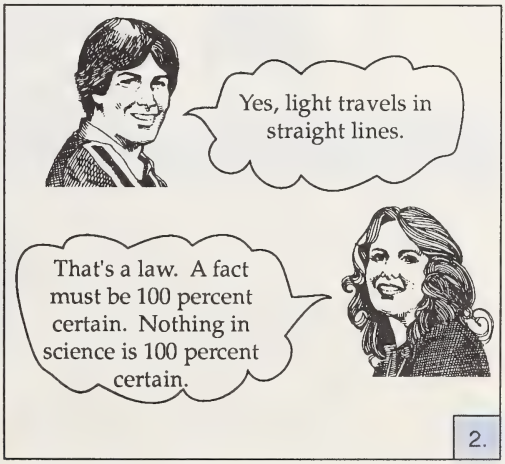


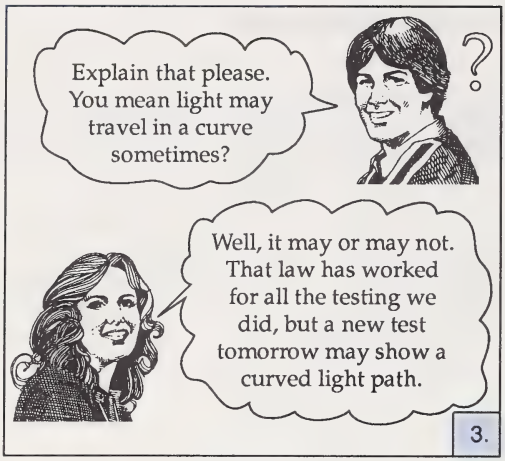



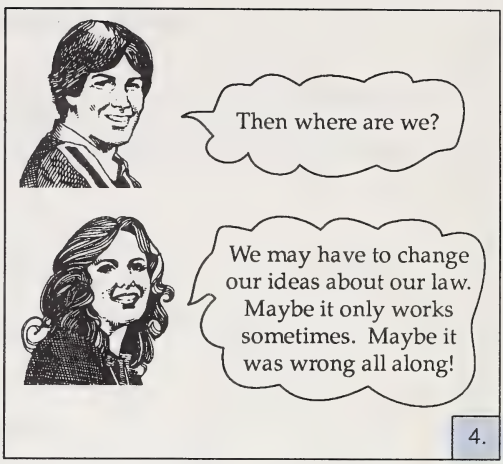
Now – about the sound experiment . . .

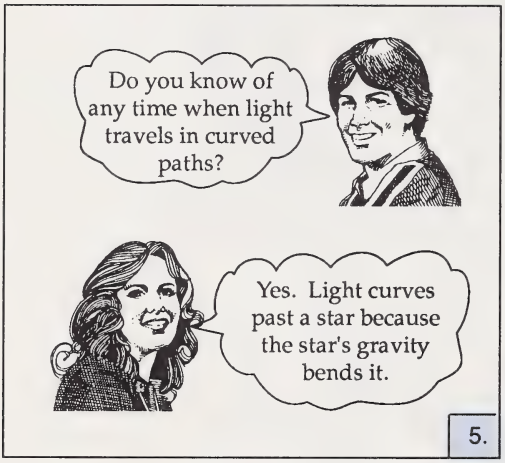


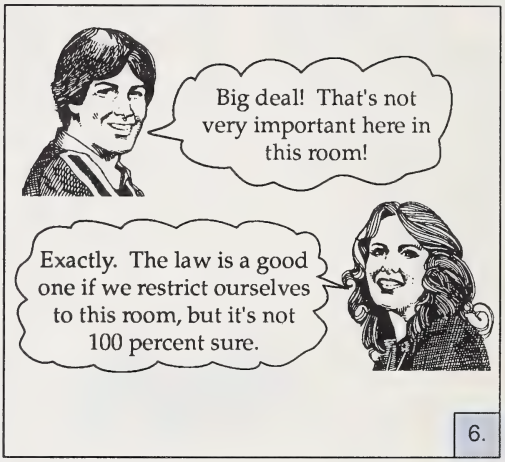



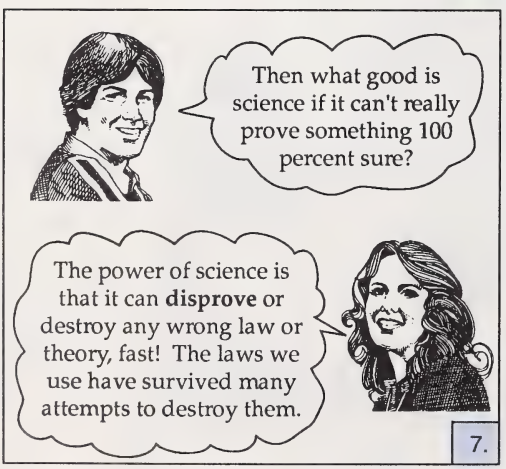



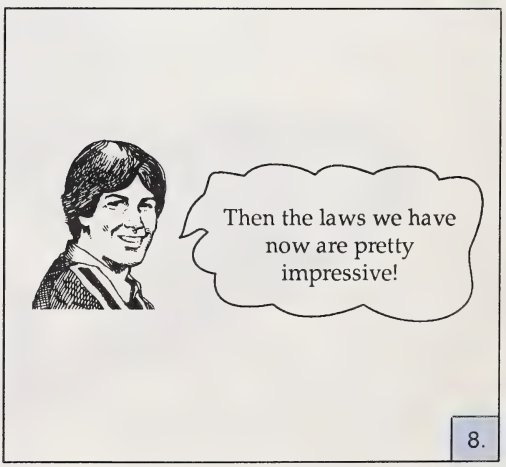

Explain that please. You mean light may travel in a curve sometimes?
?
Well, it may or may not. That law has worked for all the testing we did, but a new test tomorrow may show a curved light path.
3.


Then where are we?
We may have to change our ideas about our law. Maybe it only works sometimes. Maybe it was wrong all along!
4.


Do you know of any time when light travels in curved paths?
Yes. Light curves past a star because the star's gravity bends it.
5.


Big deal! That's not very important here in this room!
Exactly. The law is a good one if we restrict ourselves to this room, but it's not 100 percent sure.
6.


Then what good is science if it can't really prove something 100 percent sure?
The power of science is that it can **disprove** or destroy any wrong law or theory, fast! The laws we use have survived many attempts to destroy them.
7.


Then the laws we have now are pretty impressive!
8.

**fact** - anything that is done; a certain event; truth; reality

The preceding dialogue is very important in showing the nature of science. A **fact** is 100 percent sure. It is a reality. It's done. Sometimes we take it for granted that certain scientific things are facts, when technically they're not. It's just that they've survived for so long that people believe in them 100 percent. Science is always testing and retesting its foundations.

Answer these questions.

1. A principle based on observation is a _____ .

2. An event that is 100 percent sure is a _____ .

3. An explanation of a principle is a _____ .

4. Before you can build a device based on some natural phenomenon, you should

   _____

   _____

   _____

The next two questions each state something about a natural phenomenon. Put the following steps for developing technology in order of occurence by writing *first*, *second*, or *third* beside them.

5. Make a telescope. _____
   Light bends when it goes through a lens. _____
   A lens can focus an image. _____

6. Larger objects make lower sounds. _____
   Vibrating objects can make sound. _____
   Make a tuning fork for a certain note. _____

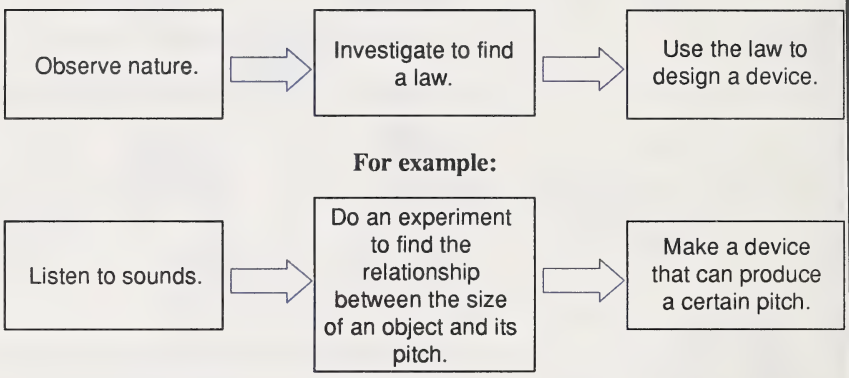
Check your answers by turning to the Appendix, Section 2: Activity 3.

## Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

### Extra Help

Look at this chart. It shows the steps in developing technology or devices.




1. Here are some devices and some laws. Draw a line connecting the law to the device it's based on. (One has been done as an example.)

| Device | Law |
|---|---|
| periscope • | • opposite poles of a magnet attract |
| weather vane • | • white things reflect light and heat |
| clock • | • a pendulum rocks at a steady pace |
| light clothes • | • light travels in straight lines |
| compass • | • pointed objects point into the wind |

2. When investigating something, what is your conclusion based on?

_____

_____

3. Use the following terms to finish this paragraph. Each term may be used more than once.
*facts, test, theories, laws, phenomenon*

Technology is developed after some _____ are known about a natural _____ . _____ are 100 percent certain events. In science, facts are confused with _____ and _____ . Laws are believed more and more every time they survive another _____ .

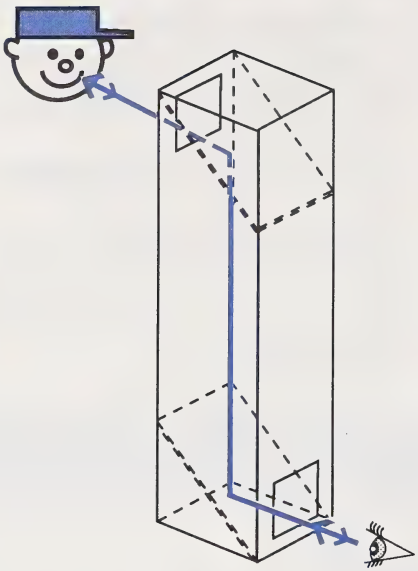
Check your answers by turning to the Appendix, Section 2: Extra Help.

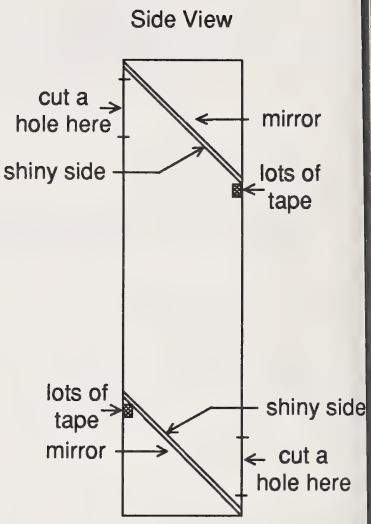
## Enrichment

Build a periscope – one of the devices mentioned in this section. Here are some hints to guide you.

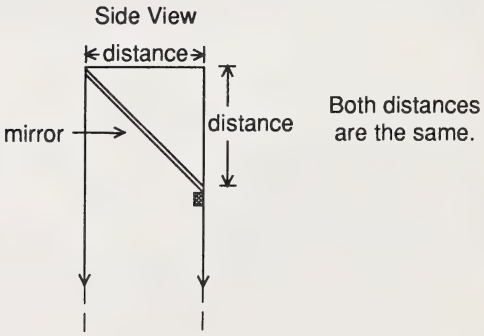
What you need to do is to put two mirrors into a box or tube so that they are at a 45° angle to the box and they face each other. A one- or two-litre milk container makes a good box for this.

**The Periscope**






To get the mirrors at a 45° angle, make sure that they go down the box the same distance that they go across.



You can make the periscope as long as you wish to, but the longer it is, the smaller the image will be that you seem to see.

Here it is in action!

## Conclusion

In this section you learned the terms

- fact
- law
- phenomenon
- theory

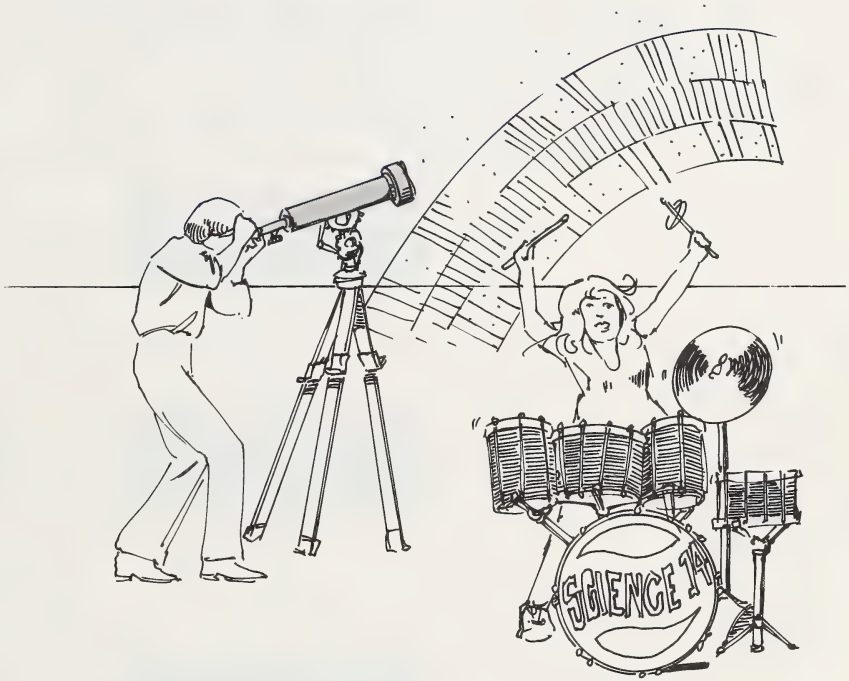
You also studied a method of designing things. You should now understand that in order to design something, you should know something about the principles at work, and in order to know these principles, you must observe nature and investigate the phenomena you are working with.

Assignment Booklet

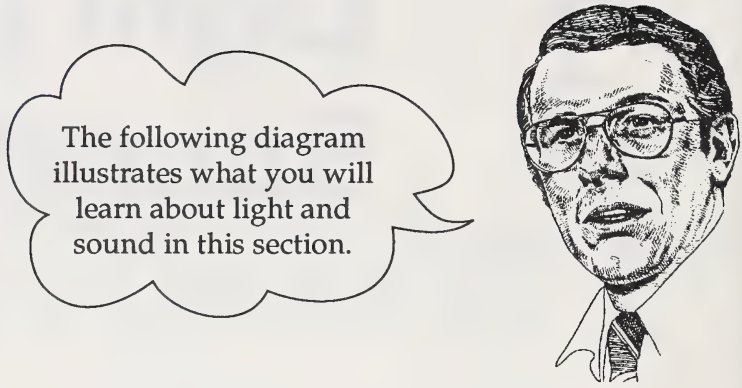
**ASSIGNMENT**

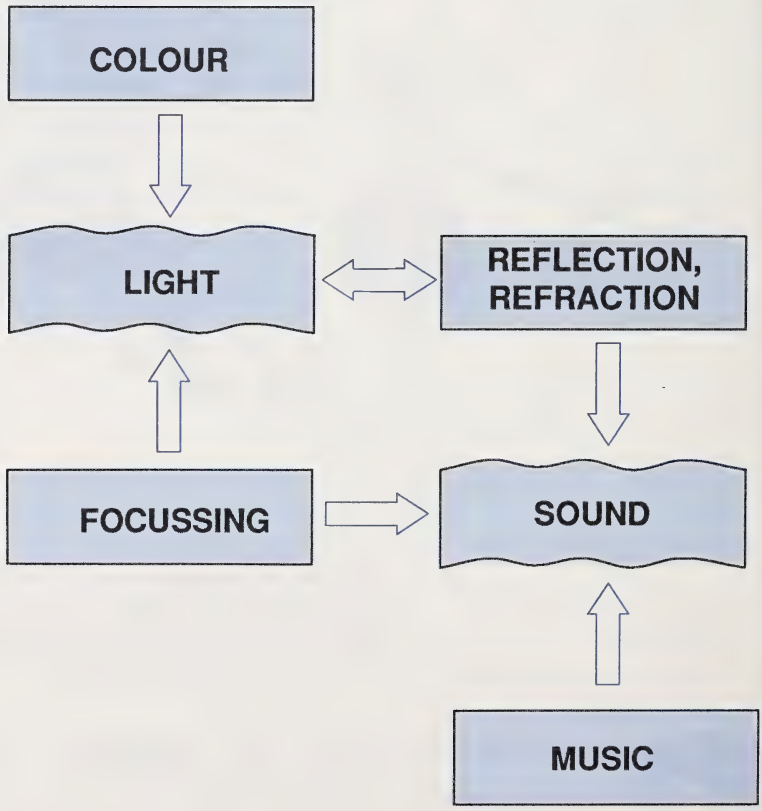
Turn to your Assignment Booklet and do the assignment for Section 2.

# 3 Light and Sound




Have you ever wondered what colour is? Why do you think a violin is smaller than a stand-up bass? How does your body turn light and sound into sight and hearing? In this section you will learn some principles of light and sound and relate them to some basic technologies.


The following diagram illustrates what you will learn about light and sound in this section.


COLOUR
LIGHT
REFLECTION, REFRACTION
FOCUSSING
SOUND
MUSIC

## Activity 1: The Energy of Light – Intensity and Colour

**photon** - a package or bundle of energy that travels at the speed of light
It has particle and wave characteristics.

Scientists have had a hard time making a theory of what light is. Today you picture light as streams of particle-like bundles of energy. These energy bundles are called **photons**. They travel at a speed of 300 000 kilometres per second! At that speed, they could go around the Earth seven and a half times in one second! Photons behave like particles (think of a steady stream of sand particles) and like waves (think of water waves).

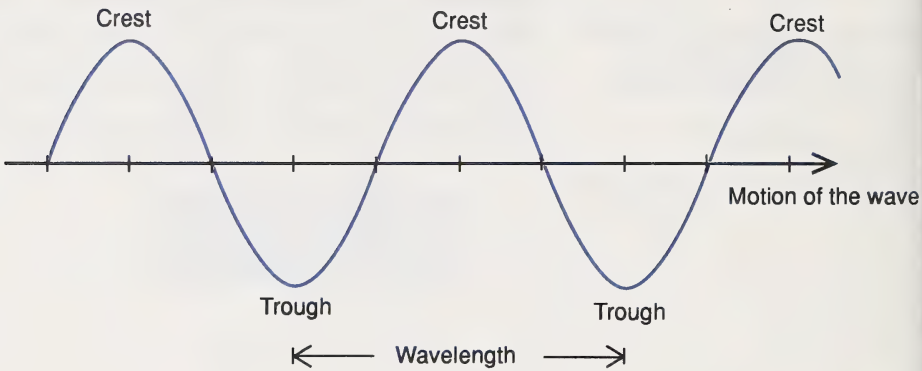
**intensity** - how bright a certain beam of light is

A bright light is very **intense** while a dim one is not. A bright light has many, many photons. A dim light has fewer photons.

**wave** - a transfer of energy in a vibrating medium

The colour of light does not depend on the number of photons. Colour is determined by the properties of the individual photons. **Waves** have frequencies and wavelengths. Study the following diagram.

**A Model of a Wave**




**wavelength** - the length of an entire wave
The distance from one crest to the next, or one trough to the next.

The length of a whole wave is called its **wavelength**. It is a distance and is therefore measured in metres (or a fraction of a metre, or several thousands of metres, etc.).

**frequency** - the number of waves that pass a place in one second; measured in Hertz

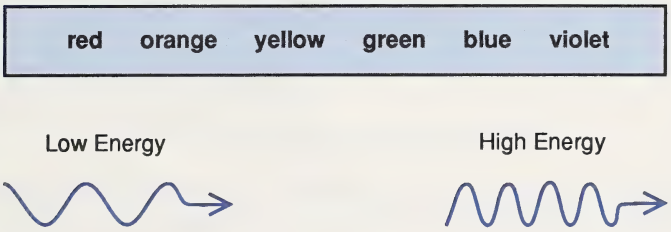
The number of waves that pass by a certain place in one second is called the **frequency** of the wave. It is measured in units that mean *waves per second.* This unit is the Hertz (Hz). If ten waves per second pass by a location, then they are 10 Hz waves.

Different colours of light have different wavelengths and frequencies. Wavelengths of light are measured in ten millionths of a metre!

**spectrum** - the colours of the rainbow – red, orange, yellow, green, blue, and violet

**The Visible Spectrum**

- Lower Frequency
- Longer Wavelength
- Higher Frequency
- Shorter Wavelength




When all these colours are mixed together, the result is white light. Blackness is the absence of all the colours.

1. Compare a bright white light to a dim white light.

2. Compare two equally bright lights, one blue and one red.

3. Compare a dim red light to a bright green light.

4. According to the diagram of "The Visible Spectrum," what is the relationship between the energy and the frequency of a photon?

Check your answers by turning to the Appendix, Section 3: Activity 1.

## Activity 2: Applying the Theory

Do **either** Investigation A **or** Investigation B of this activity.

**photometer** - a device that measures the intensity of light

### Investigation A: Comparing the Intensities of Light Sources

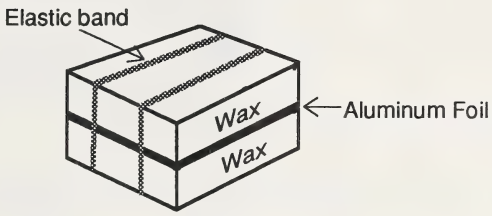
Light meters are devices that use photons to produce electricity. They are expensive to buy, so you will construct a **comparative photometer** (a term for an instrument which helps you to tell which of two lights is brighter).

#### Materials You Need

- sealing wax (two blocks about 5 cm × 5 cm) (Parowax[1] is the product.)
- aluminum foil (5 cm × 5 cm)
- elastic band or other fastener
- metre stick or tape measure
- two light sources

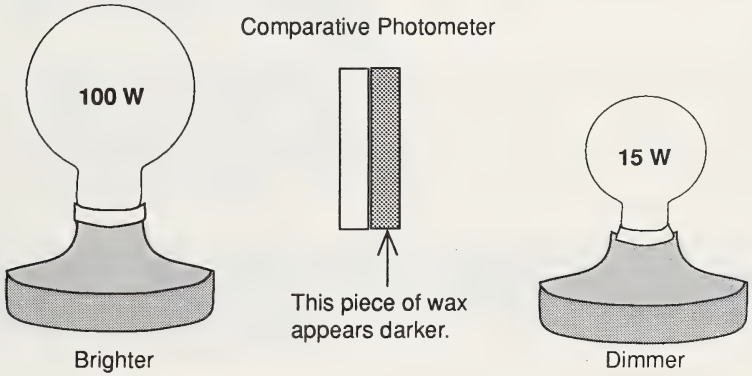
[1] Parowax is a trademark name of *Conros Corporation*, Scarborough, Ontario.

Make an aluminum foil *sandwich* and fasten it together. That's all!




Note: The two pieces of wax should be the same thickness.

Here's how it works. If two lights shine on your photometer, the brighter one will produce the shadow of the foil on the wax facing the dimmer one.




Try it. If you turn over the device, the piece of wax near the dim bulb will still be darker. Now put it to work.

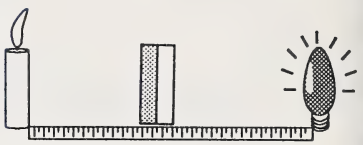
## Steps to Follow

**STEP A**

Get any two light sources that are about the same brightness.

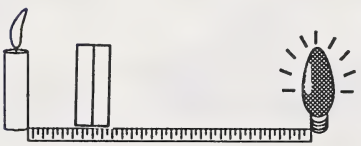
**STEP B**

Place them about a metre apart, and put the photometer in the middle.



**STEP C**

If one of the wax sides is darker, move the photometer closer to the dimmer light. Find where both pieces of wax are the same brightness. Mark the spot.



**STEP D**

Turn the photometer over and repeat step B and step C.

**STEP E**

Find the middle of the two points you marked.

## Conclusion

1. How can you decide which light is brighter?

_____

_____

2. Why did you turn the photometer over and repeat step C and step D?

_____

_____

_____

3. What could you say about your photometer if you marked the *same* spot in step D that you marked in step C?

_____

_____

_____

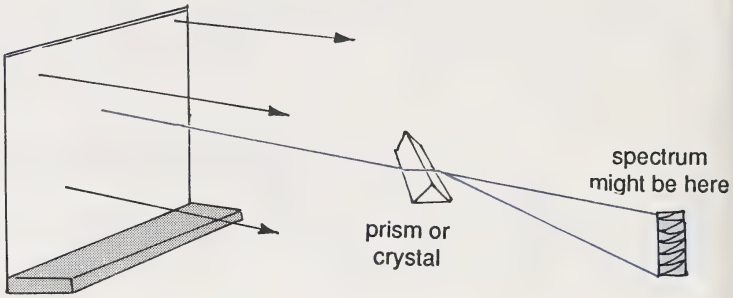
Check your answers by turning to the Appendix, Section 3: Activity 2.

**prism** - a device that makes a spectrum by refraction (A raindrop can be a prism.)

## Investigation B: Rainbow Colours

If you have access to a **prism**, or a piece of crystal that can make a spectrum, that's great! Use it. If not, you can make a rainbow the same way nature does – with a spray of water. In either case, you need a sunny day. If you're lucky enough to see an actual rainbow in the sky, that's even better. Use it with the directions for the spray-made rainbow.

If you are using a prism, place it in direct sunlight. Look all around the room for a spectrum. When you find one, turn the prism slowly until you put a spectrum where it's easy to observe.




To make a rainbow, set a garden hose on a fine spray and aim it away from the sun. With your back to the sun, look at the spray. You will see a rainbow. It's easiest to see against a dark background, so try to project the rainbow over a shaded area.

4. Do you see all the colours that are on the spectrum chart in Activity 1?

_____

5. List the colours you do see.

_____

_____

_____

6. Which colour is brightest?

_____

7. Which colour is the widest?

_____

8. The sun is yellow to your eyes. Do you see anything surprising about the spectrum?

_____

_____

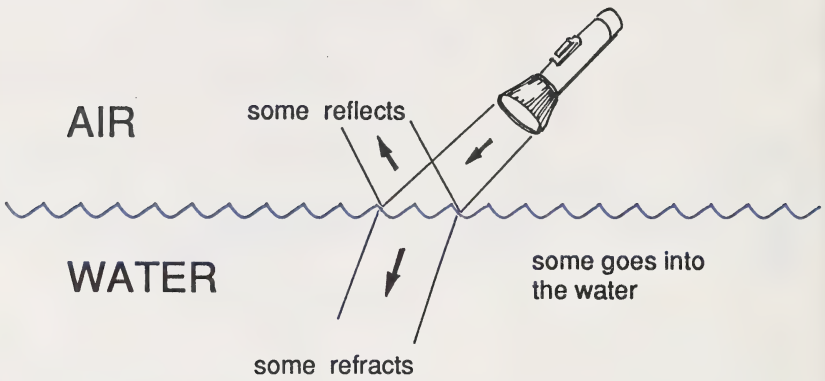
_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 2.

## Activity 3: Focussing Light

Look what happens when light hits a surface of water.




**reflection** - bouncing, when light bounces off a surface

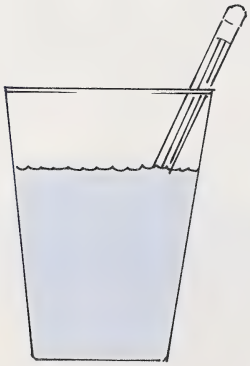
**refraction** - the bending of light when it passes from one medium to another, (for example, from air into water)

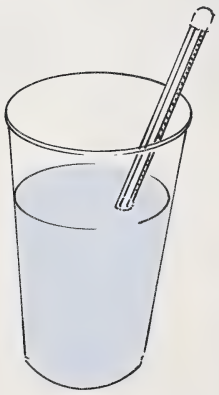
Part of the light bounces off the surface. This is **reflected** light. When light enters the water, it **refracts**.

1. Put a pencil into a glass full of water and draw its appearance.

   a. from the side

   b. from an angle



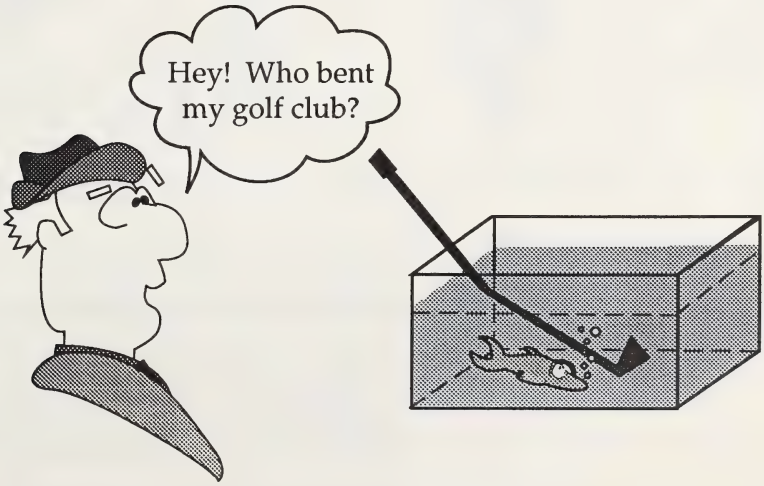


2. Place a penny under an empty glass. Observe it at an angle and draw what you see. Then add water until the glass is full and draw what you see.

Empty Full

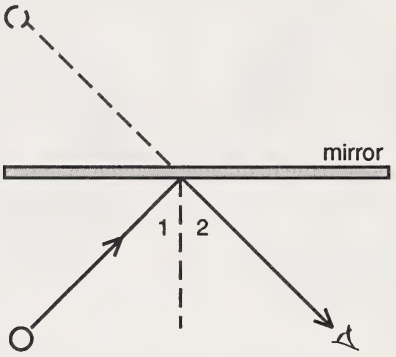
Check your answers by turning to the Appendix, Section 3: Activity 3.

When light enters water, it changes direction. It changes direction when it enters glass, diamond, or any other transparent substance. Refraction changes the direction of a light beam.



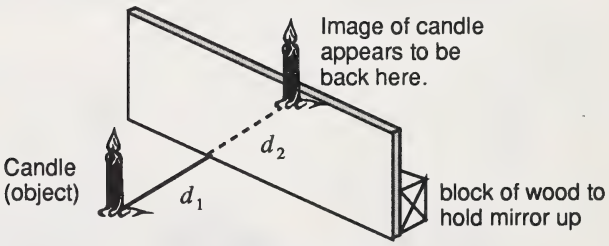
When light reflects, it leaves the reflecting surface at the same angle that it came in at. This is the *law of reflection.*

**The Law of Reflection**




Angles 1 and 2 must be equal.

When you see an object in a mirror you cannot detect that the light from the object changes direction at the mirrors surface. Therefore, the image of the object appears to be behind the mirror. The next illustration shows not only that the image appears behind the mirror but that the image appears to be as far behind the mirror as the object is in front of the mirror.




$d_1$ and $d_2$ are the same

The diagram shows a setup that can show where the image is. If you can get the materials shown in the diagram (candle, block of wood, and a mirror), try to set it up. Place a second candle (or anything thin that stands up) behind the mirror the same distance that the first candle is in front of it. If you get the right spot, the image of the candle and the candle behind the mirror will line up **no matter what angle you look at it from**.

Do **either** Investigation A **or** Investigation B.

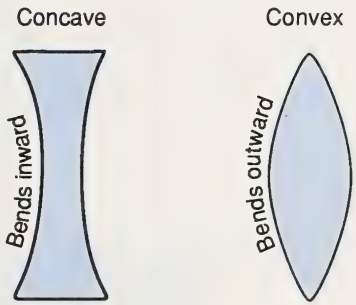
## Investigation A: Lenses

**lens** - a device that focusses light by refraction

**concave** - bends inward

**convex** - bends outward

There are two kinds of lenses, **concave** and **convex**. Concave lenses are thinner in the middle than on the outside. Convex lenses are just the opposite; they are wider in the middle than on the outside.




**focus** - to bring rays (of light for example) together to one point

Concave lenses spread light out, while convex lenses **focus** light.

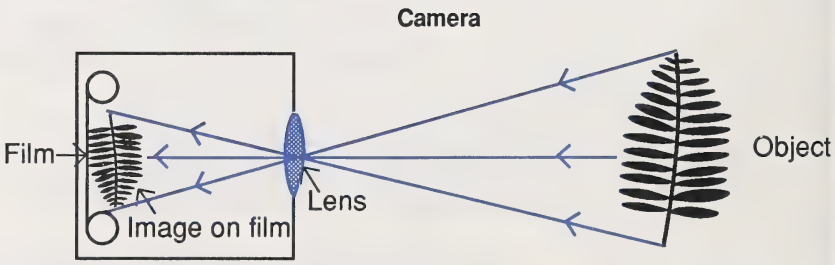
3. Take a hand lens (magnifying glass), or put a small drop of water on a piece of glass. Put the lens or drop close to some small type (a newspaper) and describe how the print appears.

4. Move the lens farther away from the print until it is at least 30 cm away. Describe how the image of the print changes as you do this.

5. Darken the room except for one window. Place the lens near the wall opposite the window, and move it closer and then farther until you see an image of the window on the wall. Describe this image. (This can't be done with the drop of water. However, the drop can make an image of a ceiling light on a table.)

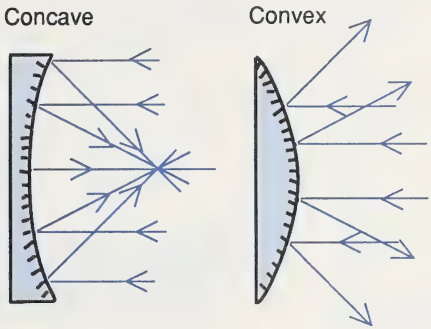
Check your answers by turning to the Appendix, Section 3: Activity 3.

A camera uses this principle.



## Investigation B: Mirrors

Mirrors can also be either concave or convex, if they have curved surfaces.




The reflecting surface is the side that is used to decide what kind of mirror it is. Convex mirrors bend outward, while concave mirrors bend inward. Convex mirrors spread light out, while concave mirrors focus light.

6. Take a shiny spoon and find your reflection in its back side. Describe the reflection.

_____

_____

_____

7. Holding the spoon at least 30 cm away from you, find your reflection on the front side of the spoon. Describe your reflection.

_____

_____

_____

8. With the front side of the spoon still toward you, move the spoon as close to your eye as you can and describe how the image changes as you do this.

_____

_____

_____

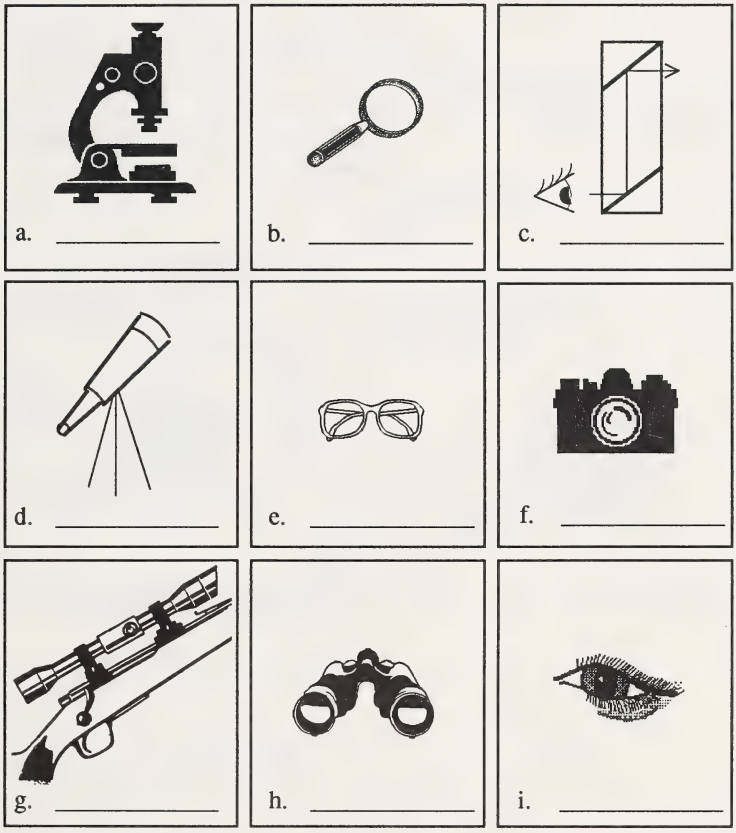
_____

Check your answers by turning to the Appendix, Section 3: Activity 3.

## Activity 4: Optical Instruments

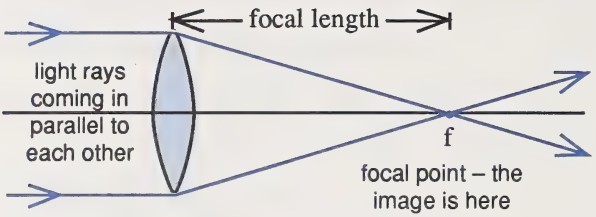
Lenses and mirrors are used in a variety of optical instruments.

1. Label as many of these instruments as you can.




Magnifying glasses and eye glasses are optical instruments that use only one lens. Microscopes, binoculars, and telescopes have two or more lenses. A convex rearview mirror and a concave shaving mirror use only one mirror. Focussing lenses and mirrors have the following characteristics.

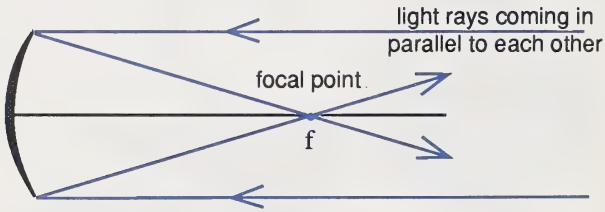
**CONVEX LENS**




**focal length** - the distance from the lens to the focal point

The distance from the lens to f is called the **focal length** of the lens. If an object is very far from the lens, light from that object enters the lens nearly parallel.

**CONCAVE MIRROR**




The distance from the mirror to f is the focal length of the mirror.

## Investigation A: Lenses, Mirrors, and Telescopes

Do **either** Part I **or** Part II; then complete Part III.

### Part I – Finding the Focal Length of a Lens

#### Materials You Need

- hand lens
- printed material (newspaper, magazine, etc.)
- ruler or measuring tape

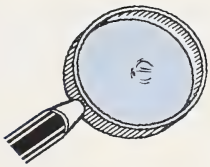
#### Steps to Follow

**STEP A**

Hold the lens close enough to an object (print) to get a right-side-up image.


**STEP B**

Move the lens away from the print until you find the place where the image has disappeared.



**STEP C**

Measure the distance from the lens to the print. This is the focal length (f).

f = _____

## Part II – Finding the Focal Length of a Mirror

### Materials You Need

- shaving mirror (make-up mirror)
- ruler

### Steps to Follow

**STEP A**

Hold the mirror close enough to your face to see a right-side-up image. (It's large.)

**STEP B**

Move the mirror back from you until your image disappears.

**STEP C**

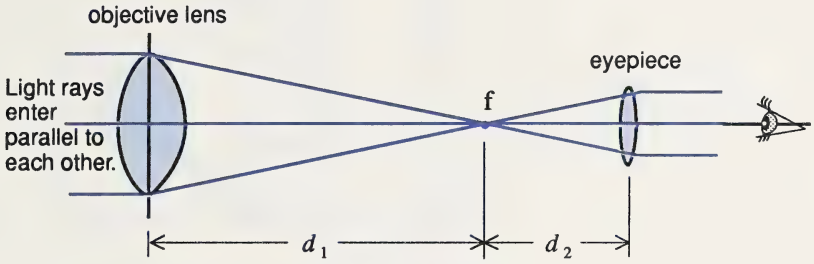
Measure the distance from the mirror to your eye. This is the focal length (f).

f = _____

Check your answers by turning to the Appendix, Section 3: Activity 4.

## Part III – The Homemade Telescope

Most optical instruments use more than one mirror or lens. Study this diagram that shows how a telescope works.




- $d_1$ is the focal length of the objective lens
- $d_2$ is the focal length of the eyepiece

The objective lens produces an image at f, its focal point. The eyepiece magnifies this image further. If you divide $d_1$ by $d_2$ you get the power of the telescope. A microscope works the same way.

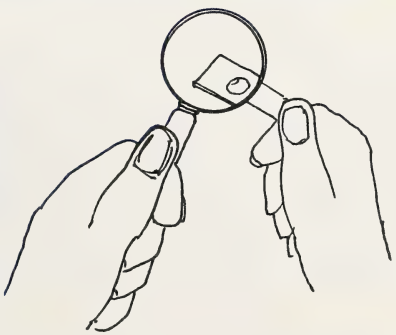
### Materials You Need

- hand lens
- water
- microscope slide
- printed material (newspaper, etc.)

### Steps to Follow

STEP A

Take a hand lens and place a tiny drop of water on a small piece of glass, (like a microscope slide). Use them together to make a *telescope* and look at the print of a newspaper.

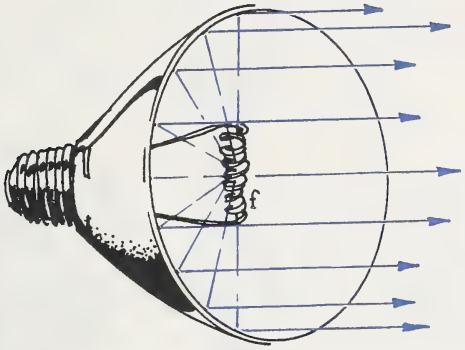


| STEP B | OBSERVATION |
| --- | --- |
| Adjust the two lenses until you see a clear image of the type in the drop in the hand lens. | 2. Describe the image. |

| STEP C | OBSERVATION |
| --- | --- |
| Reverse the hand lens and the drop. Focus the image by moving one lens, or both, closer to the print. Move them farther away. | 3. What combination gives you the best image? |

Check your answers by turning to the Appendix, Section 3: Activity 4.

Reflectors for lights, like the headlights of a car, are focussing mirrors used in reverse. The light bulb is placed at the focus of the mirror. This diagram shows how it works.




The filament is at f, the focal point.

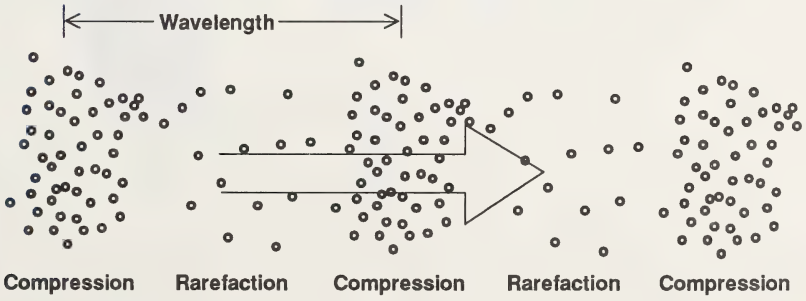
## Activity 5: Sound – Theory and Reflections

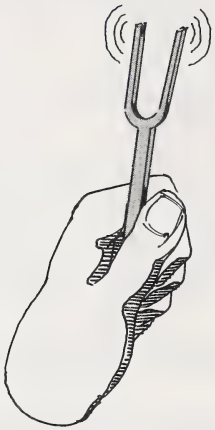
Sound is very different than light, but it has a common characteristic. Sound is a wave phenomenon. This means that it, too, can reflect, refract, and be focussed. Sound travels much more slowly than light. The speed of sound in air depends on the air temperature – the warmer the air, the faster sound travels through it. At 0° C the speed of sound is 332 m/s and at 18° C (room temperature) its speed is 340 m/s (that's about 1 km every 3 seconds). Sound waves have frequencies and wavelengths as do light waves. It is thought that sound is a regular **compression** of air molecules followed by a **rarefaction** of air molecules.

**compression** - when air molecules are pressed close together

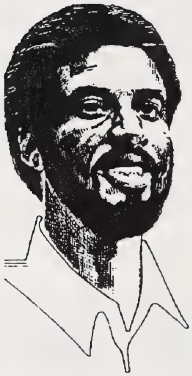
**rarefaction** - when air molecules are spread farther apart

**Sound Wave Model**





Why can I hear that tuning fork?

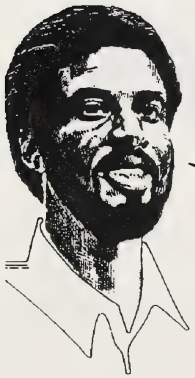


It makes the air vibrate. The metal compresses and spreads apart the air molecules.

I hear air molecules?

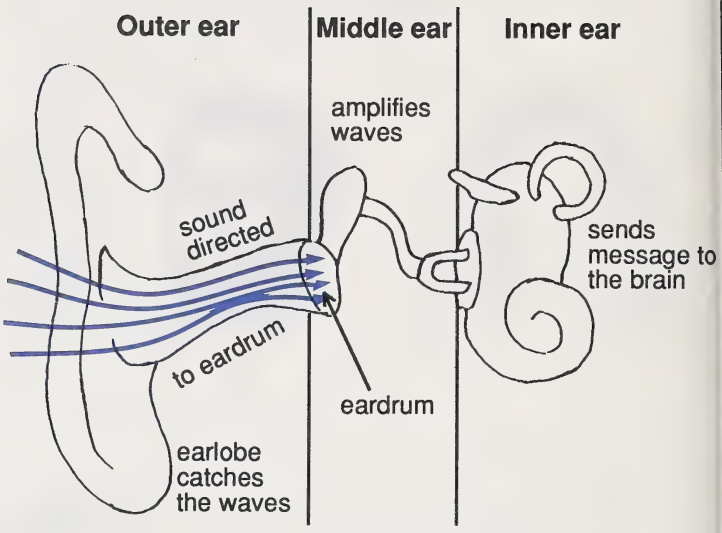
Not quite. The sound wave hits your ear and vibrates your eardrum. This vibration is coded as hearing by your brain.

Why are ears shaped so funny?



The shape lets sound from all directions reflect into the ear canal. Look at this diagram.

**Human Ear**




1. If sound is a compression wave of air molecules, then can sound travel in outer space? Why or why not?

_____

_____

_____

2. If you have ever been underwater at a lake when a motorboat went by, you know sound can travel in water, too. What is sound in water?

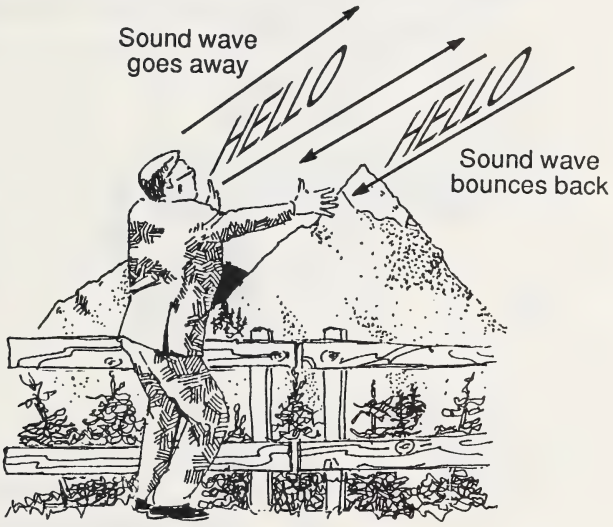
_____

_____

_____

3. Can sound travel in a solid? _____

4. Can sound travel through walls? _____




**echo** - the repetition of sound caused by a reflection

Have you ever wondered what an **echo** is? It's an example of the reflection of sound. If you yell across a valley, the sound waves will hit a cliff and bounce back to you. You hear an echo, the reflection of your voice.


5. Suppose you yell and hear your echo 8 seconds later. How wide is that valley?

**sonar** - detection system using sound reflections, **SO**und **NA**vigation and **R**anging

During World War II, **sonar** was developed to counterattack the German submarines. Sonar is an underwater echo system. Today, sonar is used to find the depth of water bodies and to find fish.


If this echo can be timed, the depth to the fish can be calculated. This is all done by the fish finder. The fisherman knows how far down to set his line.

Sound travels much faster in water than in air. It goes about 1 km/s in water.

6. If a boat sent a sonar pulse out in water 10 km deep, how long would it take for the pulse to come back?

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 5.

## Activity 6: Musical Instruments

Music is organized sound. It sounds pleasant to some people and awful to others. There are five main types of musical instruments. They all cause air to vibrate so that sound can be heard.

### Musical Instrument Types

**Stringed**
sound made by vibrating strings

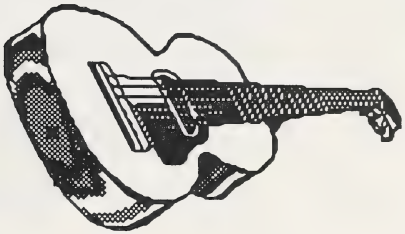
**Woodwind**
sound made by vibrating reed

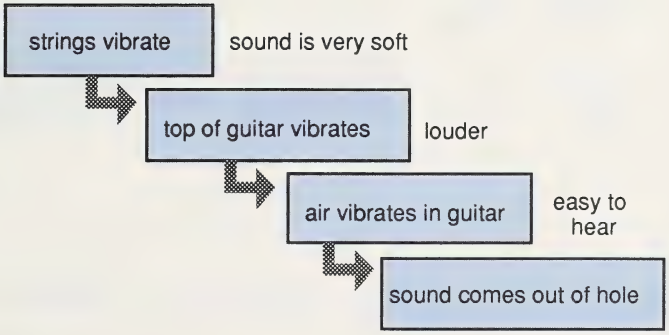
**Brass**
sound made by vibrating lips

**Percussion**
sound made by vibrating instrument (after hitting it)

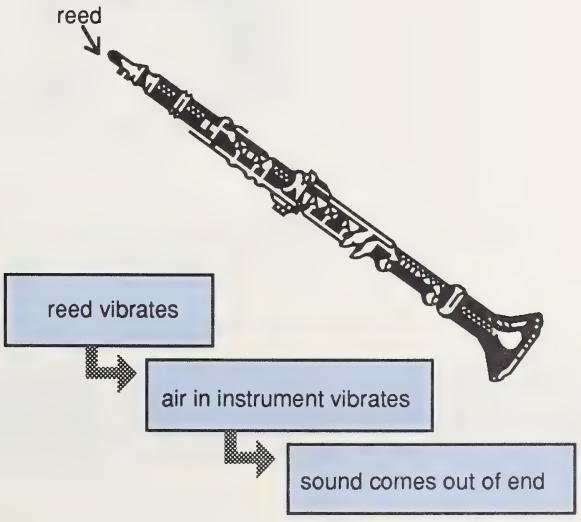
**Electronic**
sound made by vibrations produced electronically

Guitar - stringed instrument

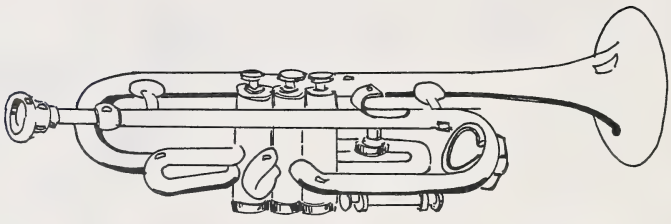





Clarinet - woodwind instrument



Trumpet - brass instrument



lips vibrate → air in tube vibrates → bell amplifies sound

Drum - percussion

drumstick vibrates the surface

↓

surface vibrates the air

Electronic instruments use more complicated technology. You will find information about them in Module 2 of this course.

1. Place the instruments listed at the right into the class that they belong to. You may have to look some of them up.

| Strings |
| --- |

| Woodwinds |
| --- |

| Brass |
| --- |

| Percussion |
| --- |

Guitar
Trumpet
Clarinet
Drum
Banjo
Trombone
Oboe
Piano
Xylophone
Harp
Tuba
Saxophone
Cymbal

Check your answers by turning to the Appendix, Section 3: Activity 6.

## Investigation: Homemade Music

Here's where you get to make a homemade musical instrument. Choose **one** of the following four plans and make it. See what kind of music (or noise) it makes.

### Part I

### Strings – A Washtub Stand-up Bass

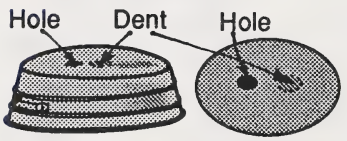
#### Materials You Need

- old wash tub (or an old pail or bucket)
- string
- wooden stick (broom handle)
- hammer
- nails

#### Steps to Follow

**STEP A**

Turn the tub upside down and use a nail to make a hole in it. Also dent it once with the hammer.




**STEP B**

Attach the string to the tub by tying a big knot in it and feeding it through the hole.

**STEP C**

Attach the string with a nail to the broom handle near the top.

Tie string here

**STEP D**

Set the parts together like this.


**STEP E**

To get different notes you lean the broom handle toward or away from the hole and pluck the string.

**STEP F**

Play a tune.

**OBSERVATION**

2. Describe the sounds your washtub bass makes.

## Part II

## Woodwind (reed instrument) – Straw Oboe

### Materials You Need

- milkshake (thick) straw
- scissors
- matches
- needle

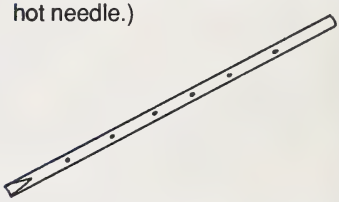
### Steps to Follow

**STEP A**

Flatten 3 cm of one end of the straw and cut a V-shaped groove in the end.

**STEP B**

Melt six holes in the straw; three for the middle fingers of each hand. You can use a hot needle to melt the holes. (You can use a pair of pliers to hold the hot needle.)



**STEP C**

Put the V-end of the straw completely into your mouth, press lightly with your lips and blow. You may have to blow quite hard to get a tone.

**STEP D**

Cover all the holes for the lowest note and open one hole at a time for higher ones. Open the holes one at a time, starting at the hole farthest away from you.

**STEP E**

Experiment with different spacings of holes to get the best notes.

**STEP F**

Play a tune.

Note: If you have another straw, cut the end and blow before you melt any holes.

**OBSERVATIONS**

3. Describe the sound your straw oboe makes.

## Part III

## Percussion – Water Drums

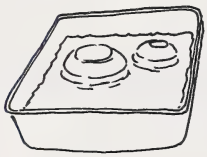
### Materials You Need

- plastic bowls
- bathtub, washtub, or a large container for water, (pails are fine)
- sticks, a rubber-tipped stick or mallet is best

### Steps to Follow

**STEP A**

Float the bowls upside down in water.



**STEP B**

Hit the bowls with sticks, fingertips, or mallets.

**STEP C**

Experiment with different volumes of air in the bowls. Use several sizes and shapes of bowls.

**STEP D**

Get a rhythm going. You may even get a tune.

STEP E

Play with some other music.


**OBSERVATIONS**

4. Describe the sound your water drums make.

## Part IV

## Brass – Garden Hose Trumpet

### Materials You Need

- a piece of garden hose about 2 m long
- a bleach bottle
- scissors or sharp knife
- a mouthpiece from a real brass instrument (if possible)
- tape

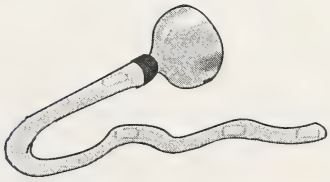
### Steps to Follow

STEP A

Cut the bleach bottle in half.

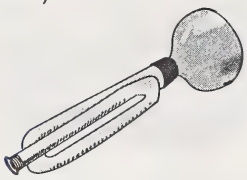

STEP B

Attach the top half of the bottle into the hose. Tape it so it is on tightly.



**STEP C**

Attach the mouthpiece to the other end. If you don't have a mouthpiece, just use the end as it is. Bend to a trumpet shape (optional).



**STEP D**

To play it, press your lips together and force air through them like you are trying to sound like an elephant. Don't blow.

**STEP E**

Change how tightly you are pressing your lips together to get different sounds. Unless you really play a brass instrument you won't get much of a tune.

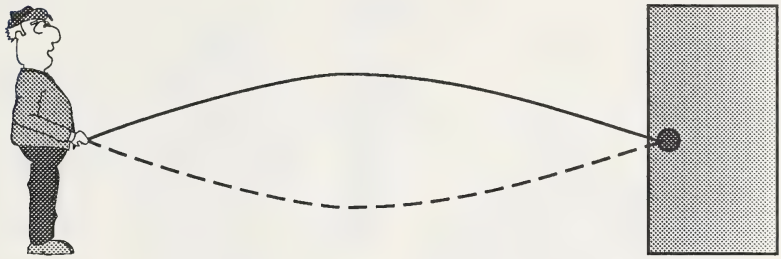
**OBSERVATIONS**

5. Describe the sound your trumpet makes.

**standing wave -** a wave that does not seem to be going anywhere

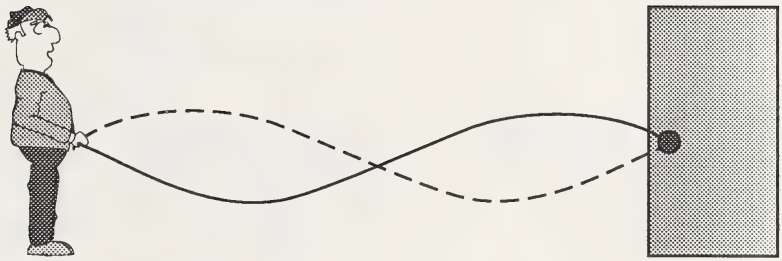
Musical instruments make **standing waves** inside them. These standing waves have a definite tone, determined by their wavelength and frequency.

Take a rope and attach it to any solid object, or have someone else hold it still. Wave it up and down slowly until it looks like this.

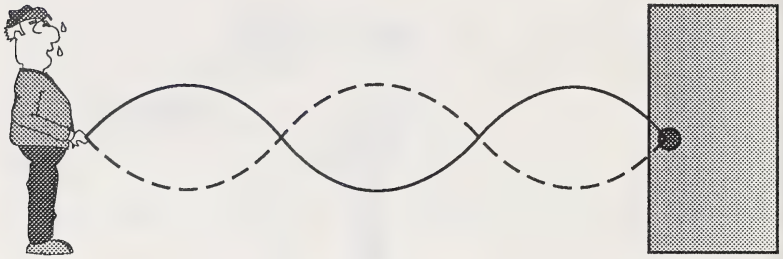


This is a standing wave.

Now speed up your up-and-down motion until it looks like this.



This is another standing wave. Notice that its wavelength is shorter than the first one. This would represent a higher pitched note. If you work really hard, you can move the rope fast enough to get even more standing waves. Here's a picture of the next one.



6. What can you say about the pitch of a note and the length of the standing wave that makes it?

_____

_____

_____

7. Frequency increases when the wavelength gets shorter. What can you say about frequency and pitch?

_____

_____

Check your answers by turning to the Appendix, Section 3: Activity 6.

Humans can hear sounds that vibrate from 20 Hz to about 20 000 Hz. Older people often can't hear the high frequencies. People in their fifties may only be able to hear up to 12 000 Hz. Sound waves above 20 000 Hz are called **ultrasonic**. Ultrasound has many medical applications.

**ultrasound** - sound with frequencies above human hearing

## Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

## Extra Help

In this section you looked at two wave phenomena; light and sound. You also learned that the properties of the wave – frequency and wavelength – determine the colour of light or the pitch of sound.

1. Complete this chart comparing sound with light. Remember, they are very different things.

| | Light | Sound |
|---|---|---|
| Frequency (determined by wavelength) | | |
| Speed | | |
| Theory – what they are | | |

Light and sound can be focussed by reflection (bouncing off a surface), or by refraction (entering another substance). Optical instruments use the properties of lenses and mirrors.

2. Name two optical instruments that use lenses.

_____

_____

3. Name two optical instruments that use mirrors.

_____

_____

Musical instruments use several methods to make standing waves. The shorter the wavelength, the higher the pitch of the sound. Instruments can be strings, woodwinds, brass, percussion, or electronic.

4. Name two instruments for each of these four classes:

   Strings _____ , _____

   Woodwind _____ , _____

   Brass _____ , _____

   Percussion _____ , _____

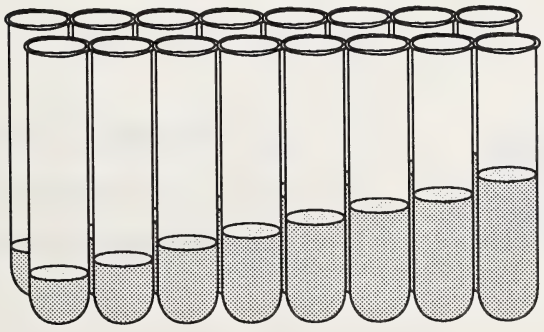
Check your answers by turning to the Appendix, Section 3: Extra Help.

A rainbow (or spectrum) has six easily recognized colours: red, orange, yellow, green, blue, and violet. If you learn ROY – G – BV then it's easier to remember them.

## Enrichment

1. Sound intensity is measured in decibels. Look up the meaning of this term and find out if it's true that loud rock concerts are a hazard to people's hearing.

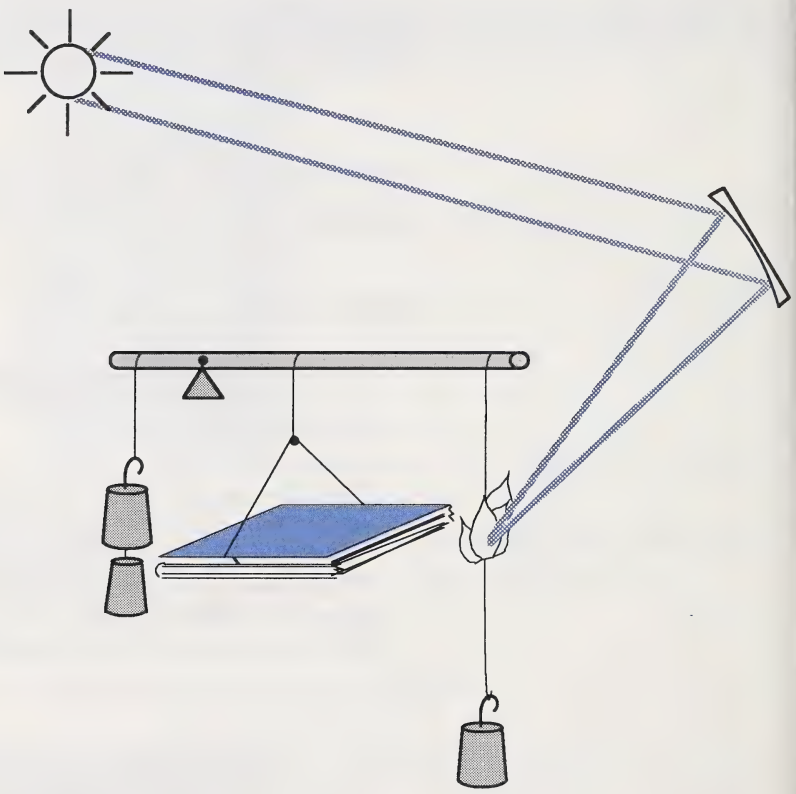
2. Construct a pan pipe out of water-filled test tubes or vials (or any tube you can find). Blow across the top of the vials and tune it with an existing instrument (i.e., piano) by adding or removing water. An eye dropper would help here. If you want more than eight notes, make two rows of tubes as shown. Put one row 1 cm above the other. Use masking tape to hold the tubes together.



## Conclusion

In this section you learned about two wave phenomena. You saw that they can be focussed, directed, and used to make optical and musical instruments. You studied the different colours of white light and the different pitches of sound.

You actually built and tested an optical instrument and a musical instrument.



Assignment Booklet

### ASSIGNMENT

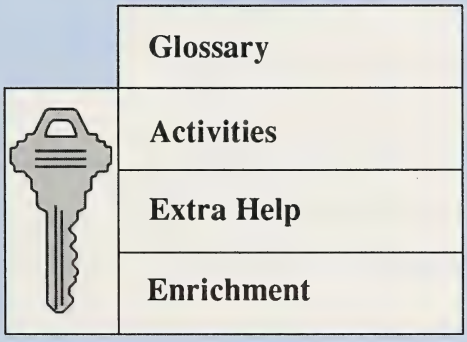
Turn to your Assignment Booklet and do the assignment for Section 3.

## MODULE SUMMARY

When people need or want something, they design it. In order to design things, however, you need to know some scientific principles about a given phenomenon.

Light and sound are two phenomena that have been used in a wide range of technologies. People have used them for deadly purposes, as well as for peaceful ones.

# Appendix



## Glossary

| | |
|---|---|
| **Brass instruments** | • a class of musical instruments that use vibrating lips to make sound |
| **Compression** | • pressed together (In the case of sound waves it would be air molecules that are compressed.) |
| **Concave** | • bends inward |
| **Convex** | • bends outward |
| **Echo** | • a reflection of sound |
| **Electronic instrument** | • a class of musical instruments that use electronically produced vibrations to make sound |
| **Fact** | • a certain event; truth; reality |
| **Focal length** | • distance from a lens, or curved mirror, to the focal point |
| **Focus** | • the place where parallel light rays come together because of a lens or curved mirror |
| **Frequency** | • the number of waves that pass a place in one second; measured in Hertz |
| **Intensity** | • how bright light is, or how loud sound is |
| **Law** | • description of a rule in science, based on observing nature |
| **Lens** | • a device that focusses light by refraction |
| **Percussion** | • a class of musical instruments played by hitting them |
| **Phenomenon** | • any fact, event, or experience; anything that occurs |
| **Photometer** | • a device that measures light intensity |
| **Photon** | • bundle of light energy (a particle of light with wave characteristics) |
| **Pitch** | • how high or low a sound is |
| **Prism** | • a device that makes a spectrum by refraction (A raindrop can be a prism.) |

| | |
|---|---|
| **Rarefaction** | • stretching or thinning out of air molecules |
| **Reflection** | • bouncing off a surface<br>Light and sound can reflect. |
| **Refraction** | • the bending of light when it passes from one medium to another, (for example from air into water) |
| **Sonar** | • technology that uses sound reflections in water<br>**SO**und **NA**vigation and **R**anging |
| **Spectrum** | • the range of colours of visible light<br>red, orange, yellow, green, blue, violet; ROY – G – BV |
| **Standing wave** | • a wave that does not seem to be going anywhere |
| **String instrument** | • a class of musical instruments that use vibrating strings to produce sound |
| **Technology** | • all the inventions and techniques people have developed to solve practical problems; science at work |
| **Theory** | • an explanation of why events occur as they do |
| **Ultrasound** | • sound with frequencies beyond human hearing, above 20 000 Hz |
| **Wave** | • a transfer of energy in a vibrating medium |
| **Wavelength** | • length of one entire wave; crest-to-crest or trough-to-trough distance |
| **Woodwind** | • a class of musical instruments that use a vibrating reed to produce sound |

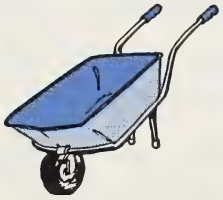
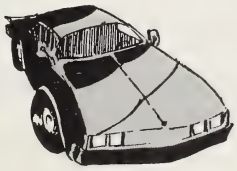
# Suggested Answers

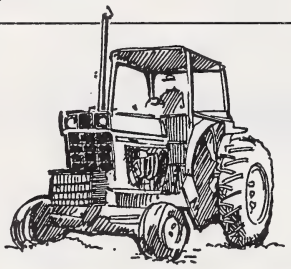
## Section 1: Activity 1

1. Here are some answers. You may have found others.

| Need (Want) | Technology or Device |
|---|---|
| cook food outdoors | **fire, barbecue, camp stove** |
| cook food indoors | **hotplate, stove** |
| lift a car to change a tire | **jack, jackscrew** |
| see very small things | **microscope, magnifying glass** |
| push a fridge up into a truck | **ramp, inclined plane** |
| have sure-footing when playing games | **running shoes, cleats** |
| stay warm outside at – 40°C | **boots, coat, hat, or materials like down, thinsulate, fiberfill, wool** |
| stay up when in water | **boat, life jacket** |

2.

| Device | Need (or Want) |
|---|---|
|  | • **to lift heavy loads and carry them** |
|  | • **to transport people from place to place quickly** |

| Device | Need (or Want) |
|---|---|
|  | • to see things that are far away |
|  | • to provide a steady source of electricity |
|  | • to push a thread through material |
|  | • to allow farmers to work very large farms |
|  | • to project a voice farther than normal |

| Device | Need (or Want) |
|---|---|
|  | • **to carry things into orbit around the Earth** |

## Section 1: Activity 2

Here are some possible answers. If you have other similar ones, that's fine.

Task 1 – Lift a heavy boulder 2 m.

**Condition 1:**
- Use a bulldozer or a tractor with a front-end loader.
- Use a crane.
- Tie a pulley over the boulder and pull it with a vehicle.

**Condition 2:**
- Cars and other vehicles use electricity so they won't count for this exercise.
- Use a strong ramp or make one out of sand.
- Use a pulley system.
- Use a lever.

**Condition 3:**
- Gather several friends and lift the boulder.

Task 2 – Read in bed at night.

**Condition 1:**
- Turn on a light or flashlight.

**Condition 2:**
- Use a candle.
- Use a kerosene lamp.

**Condition 3:**
- Hope that the moon is out.

Task 3 – Listen to some music performed by your favourite band.

**Condition 1:**
- Play a tape, record, video, or compact disc.

**Condition 2:**
**Condition 3:**
- Go somewhere to hear them live.

## Section 1: Activity 3

1. • things to fix the ozone hole
   • three-dimensional TV
   • flying cars

   There are many possibilities for this question.

2. Here are some of the many problems.

   • What materials should you use?
   • "Where do I start?" (You can't get a good idea.)
   • You have an idea that uses gears (or something else), but you don't know how they work.
   • You have too many ideas! Which one will you use?

   This question is open-ended. This means that you may have several other ideas as well.

## Section 1: Activity 4

1. T → S
2. T → S
3. S → T
4. S → T

## Section 1: Follow-up Activities

### Extra Help

1. a. plows, tractors, and refrigerators
   b. radios, televisions, and satellites
   c. toothpaste, combs, and mirrors

2. fire → roads → electricity → space shuttle

### Enrichment

1. Here are some ideas to consider:

   • Do the foods need to be cooked?
   • What sources of heat are available?
   • Can you do it inside a home?
   • Do you know of any high-tech ideas that you could use?

2. Here are some ideas to consider:

   - There is no electricity or central heating.
   - Does your kitchen have a fireplace?
   - Where is water stored? heated?
   - What utensils would a cook use?
   - What is used to keep things cold?

## Section 2: Activity 1

1. a. an event, anything that occurs
   b. a rule, pattern, or principle that has been established by observing events
   c. an explanation of why events occur as they do

2. a. law
   b. theory
   c. theory

## Section 2: Activity 2

### Investigation A: Light

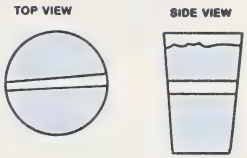
**STEP E**

**OBSERVATION**

It's straight. The beam might spread a bit. Check your alignment if you can't see it.


**STEP G**

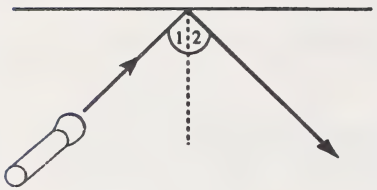
**OBSERVATION**



**STEP H**

**OBSERVATION**

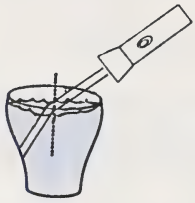
Angles 1 and 2 are equal.




**STEP I**

**OBSERVATION**

The beam is straight. However, if you look carefully, you will see that it angles a bit from its original direction.



### Investigation B: Sound

1. As more water was put in the bottle, the pitch went **up**.

2. As more water was put in the bottle, the size of the airspace got **smaller**.

**STEP D**

**OBSERVATION**

There is probably no relationship between glass size and pitch. Big glasses are sometimes higher and sometimes lower than small ones.

3. As more water is put in the cup, the pitch **goes down**.

4. The biggest difference in pitch happens when the water is **very near the top**.

## Section 2: Activity 3

1. law

2. fact

3. theory

4. test or experiment to learn some law or principle that's working

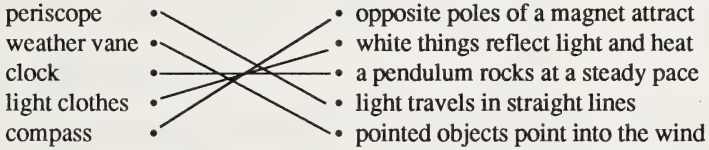
5. Make a telescope. third
   Light bends when it goes through a lens. first
   A lens can focus an image second

6. Larger objects make lower sounds. second
   Vibrating objects can make sound. first
   Make a tuning fork for a certain note. third

## Section 2: Follow-up Activities

### Extra Help

1. **Device** **Law**




2. Your conclusion will depend on your observations.

3. Technology is developed after some laws are known about a natural phenomenon. Facts are 100 percent certain events. In science, facts are confused with laws and theories. Laws are believed more and more everytime they survive another test.

### Enrichment

Make sure that the mirrors are set at 45° angles, that the mirrors face each other, and that they line up well.

## Section 3: Activity 1

1. The bright light has more photons than the dim one.

2. They have the same number of photons, but the blue light photons have shorter wavelengths than the red light photons.

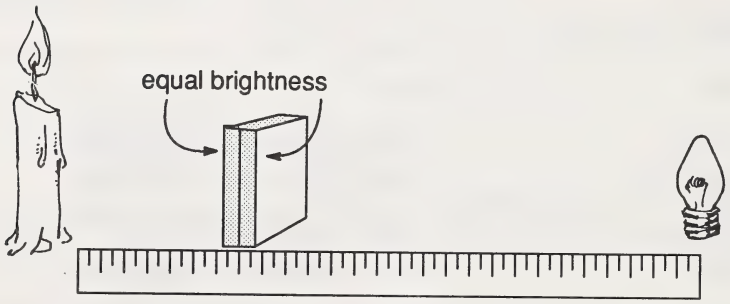
3. The dim red light has fewer photons with longer wavelengths, while the bright green light has many photons with shorter wavelengths.

4. As the frequency increases, the energy increases (goes up).

## Section 3: Activity 2

### Investigation A: Comparing the Intensities of Light Sources

1. The brighter light is the farthest from the spot you marked. For example




The Christmas light is brighter than the candle.

2. The photometer was turned over to doublecheck your measurements and the accuracy of the photometer.

3. The photometer works well. It also means that the two wax pieces have the same thickness.

### Investigation B: Rainbow Colours

Following are the answers if you used a prism.

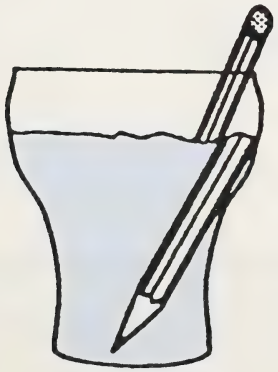
4. Yes, all the colours can be seen.
5. Red, orange, yellow, green, blue, and violet are the colours seen.
6. Green and yellow are the brightest colours.
7. Green is the widest band.
8. Yellow is a very narrow band.

Following are the answers if you used a water spray.

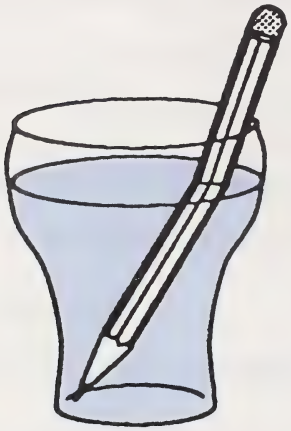
4. No, all the colours can't be seen.
5. Orange (maybe), yellow, green, blue, and violet (maybe) are the colours seen.
6. Yellow and green are the brightest colours.
7. Blue is the widest band.
8. Yellow is a faint and a narrow band.

## Section 3: Activity 3

1. a. The part of the pencil in the water appears to be thicker and at a different angle than the part of the pencil in the air.



b. The pencil appears to be at the same angle and the same thickness until it is seen in the water; then it bends to a different angle.

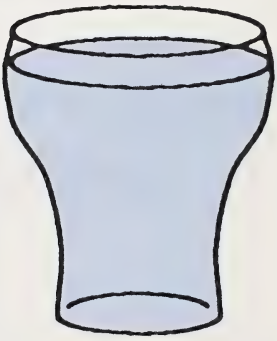


2.

Empty

penny shows clearly

Full



penny disappears

### Investigation A: Lenses

3. The print is bigger and right-side-up. It may be distorted if you are using a water drop.

4. As you move the lens away the print gets bigger, then disappears, and then appears again upside-down.

5. The image is a clear picture of the window (or light). The image is upside-down and smaller than the actual window (or light).

### Investigation B: Mirrors

6. The image is smaller than life and right-side-up. It's distorted a bit, too.

7. The image is small and upside-down.

8. As you move closer the image gets larger, disappears, and appears again right-side-up and very large. (You have to get the spoon very close to your eye to see the right-side-up image.)

## Section 3: Activity 4

1. a. microscope
   b. hand lens or magnifying glass
   c. periscope
   d. telescope
   e. eyeglasses
   f. camera
   g. rifle scope
   h. binoculars
   i. human eye

### Investigation A: Lenses, Mirrors, and Telescopes

**Part I – Finding the Focal Length of a Lens**

STEP C

Measure the distance from the lens to the print. This is the focal length (f).

focal length (f) = 7.5 cm
(large lens)

focal length (f) = 3.75 cm
(small lens)

**Part II – Finding the Focal Length of a Mirror**

STEP C

Measure the distance from the lens to the print. This is the focal length (f).

Your focal length will be different for each mirror. It's probably about 50 cm, but answers can be far from that as well. The bigger your face in the mirror, the shorter the focal length.

**Part III – The Homemade Telescope**

STEP B

OBSERVATION

2. The image appears larger and upside-down when using the telescope.

STEP C

OBSERVATION

3. Use a small drop of water; your best image occurs when the drop is close to the print. The fact that the drop isn't very regular in shape limits you to doing it this way.

## Section 3: Activity 5

1. No, there are no molecules to compress.
2. Sound in water is a compression wave of water molecules.
3. Yes, sound can travel in a solid.
4. Yes, sound can travel through walls.
5. The valley is 1.36 km wide.
6. It would take 20 seconds for the sonar pulse to return.

## Section 3: Activity 6

1.

| | |
|---|---|
| **Strings** | guitar<br>banjo<br>harp<br>piano (The piano can also be a percussion instrument.) |

| | |
|---|---|
| **Woodwinds** | clarinet<br>oboe<br>saxophone |

| | |
|---|---|
| **Brass** | trumpet<br>trombone<br>tuba |

| | |
|---|---|
| **Percussion** | drum<br>xylophone<br>cymbal |

## Investigation: Homemade Music

**Part I**

STEP F

**OBSERVATION**

2. A washtub bass makes a low-pitched thumping note amplified by the washtub. A tune is possible.

**Part II**

STEP F

**OBSERVATION**

3. A straw oboe makes a loud buzzing note. A tune is possible if the holes are placed correctly. (This is very hard to do.)

**Part III**

STEP E

**OBSERVATION**

4. A water drum makes a deep resonating thump. The pitch is lower when there is very little water is in the bowl. A rubber mallet works best.

**Part IV**

STEP E

**OBSERVATION**

5. A hose trombone makes a sick animal call – a very ugly sound by most people's standards. A trumpet player could make it sound nice though.

6. The pitch is higher when the wavelength is shorter.

7. When the frequency is high, the pitch is also high.

## Section 3: Follow-up Activities

### Extra Help

1.

| | Light | Sound |
|---|---|---|
| Frequency (determined by wavelength) | **colour** | **pitch** |
| Speed | **300 000 km/s** | **330 m/s (air)** |
| Theory – what they are | **stream of photons** | **vibrating air molecules** |

2. Optical instruments that use lenses are eyeglasses, telescopes, microscopes, rifle scopes, magnifying glasses, cameras, binoculars, and eyes.

3. Optical instruments that use mirrors are periscopes, shaving mirrors (make-up mirrors), reflecting telescopes, and reflectors for headlights.

4. Strings

   - guitar
   - banjo
   - piano
   - harp
   - mandolin

   Woodwind

   - clarinet
   - oboe
   - flute
   - saxophone

Brass

- trumpet
- trombone
- tuba
- French horn

Percussion

- drum
- xylophone
- bell
- triangle

Science 14

9SC14P21

L.R.D.C.
Producer

SECOND EDITION
1991